The AMSAT® Journal

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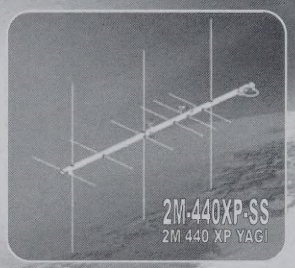

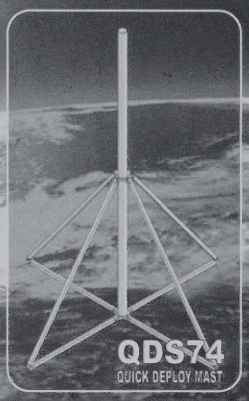

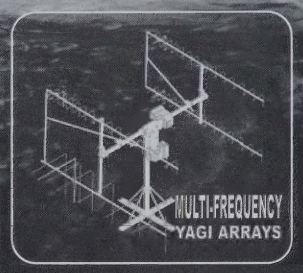

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**See our review, QST March 2016 page 60.*

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AMSAT greatly appreciates any size donation from your IRA. Please call the AMSAT Office at 301-822-4376 for help with any information or mailing instructions required by your IRA custodian.

AMSAT strongly encourages those interested in supporting AMSAT through an IRA to consult with their attorney, accountant, and tax preparer or financial advisor to determine the implications and impact of such a gift on your personal situation. Thank you for supporting AMSAT!

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2019 Annual General Meeting: AMSAT President's Report

AMSAT President, Joe Spier, K6WAO, kicked off the AMSAT Annual General Meeting at the Annapolis Hilton in Annapolis, Virginia, on October, 19, 2019, by announcing the new board of directors: Jerry Buxton and Drew Glasbrenner as incumbent members; Patrick Stoddard and Michelle Thompson coming on as new board members bringing fresh ideas; and Dr. Tom Clark, Mark Hammond and Bruce Paige continuing their current terms until next year, with alternates Brennan Price and Howie De Felice.

The senior leadership team now consists of the President, Joe Spier, K6WAO; Executive Vice President, Paul Stoetzer, N8HM; Vice President, Operations, Drew Glasbrenner, KO4MA; Vice President, Engineering, Jerry Buxton, N0JY; Vice President, User Services, Robert Bankston, KE4AL; Vice President, Development, Frank Karnauskus, N1UW; Vice President, Human Spaceflight, Frank Bauer, KA3HDO; Secretary, Brennan Price, N4QX; Treasurer, Robert Bankston, KE4AL; and Manager, Martha Saragovitz.

Spier announced the additional leaders who are appointed by the president: Vice President, Educational Relations, Dr. Alan Johnston, KU2Y; AMSAT Ambassadors — Robert Bankston, KE4AL, is looking for someone to fill that position; Hamvention Operations, Phil Smith, W1EME; Editor, AMSAT Journal, Joe Kornowski, KB6IGK; ANS Editor, Mark D. Johns, K0JM; IARU Satellite Working Group, Drew Glasbrenner, KO4MA; ARISS International Delegate, Dave Taylor, W8AAS; ARISS International Delegate, Chester Latawiec, VE3CFK; and IT Lead, Joe Fitzgerald, KM1P.

Spier explained that AMSAT's mission has not changed in 15 years:

> *AMSAT is a non-profit volunteer organization which designs, builds and operates experimental satellites and promotes space education. We work in partnership with government, industry, educational institutions and fellow Amateur Radio societies. We encourage technical and scientific innovation, and promote the training and development of skilled satellite and ground system designers and operators.*

Likewise, AMSAT's Vision has remained constant for at least the last 11 years:

> *Our Vision is to deploy satellite systems with the goal of providing wide-area and continuous coverage. AMSAT will continue active participation in human space missions and support a stream of LEO satellites developed in cooperation with the educational community and other amateur satellite groups.*

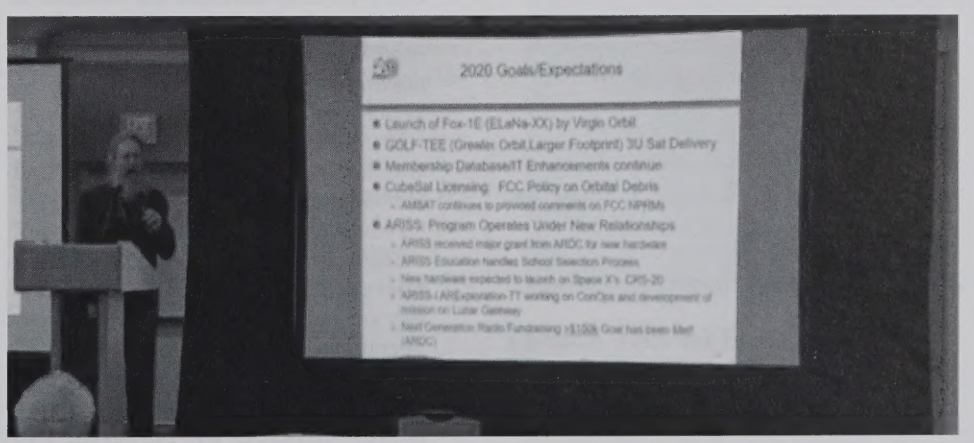
What that means in practical terms, said Spier, is "Keeping Amateur Radio in Space."

AMSAT's Accomplishments 2018-19

Spier next turned to AMSAT's key accomplishments and issues during the past 12 months, which included:

- AO-95 (Fox-1Cliff) — SSO-A launch on December 3, 2018; currently, only sending telemetry;
- AO-85 is experiencing battery issues;
- Fox-1E — the spacecraft is completed and has been assigned to ELaNa-XX;
- GOLF-TEE work is proceeding;
- AMSAT 50th Anniversary celebration;
- New five-year lease extension executed for AMSAT office space in Kensington, MD, based on the original lease terms.

In addition, Spier reported that AMSAT has


2020 Goals/Expectations
Launch of Fox-1E (ELaNa-XX) by Virgin Orbit
GOLF-TEE (Greater Orbit/Larger Footprint) 3U Sat Delivery
Membership Database/IT Enhancements continue
CubeSat Licensing: FCC Policy on Orbital Debris
ARISS: Program Operates Under New Relationships

made progress with several of its evolving partnerships. Virginia Tech is developing a camera project for GOLF-1 that will be impressive in terms of the magnitude of resolution it provides. We're also partnering with Vanderbilt University for a payload on Fox-1E — also known as RadFXSat-2, as well as the GOLF class of CubeSats, which includes an experiment using the MEM memory chips, the FinFETs.

At the Small Satellite Conference this year, AMSAT was able to negotiate a collaborative agreement with the University of Colorado at Boulder. If you look at the educational CubeSat committee, you'll see that the organization with the most small CubeSat projects running at any one time is UC Boulder.

Another development is that AMSAT built a linear transponder communications package for Fox-1E that AMSAT is offering to universities who partner with it. Basically, we hand it to them, and they put it on their satellite. HuskySat was the first one we tried this with, according to Spier.

In terms of other developments and accomplishments, Spier announced:

- AMSAT is placing the GOLF program materials in the public domain, as we did with the Fox program.
- The ARISS Program has been evolving a plan for the Lunar Gateway project, where we will have a satellite within view of the Earth for 12 hours per day.
- The *AMSAT Journal* — Joe Kornowski, KB6IGK, and his team continue to do stellar work with this major member benefit, though content is always a concern.
- AMSAT had an expanded presence at the CubeSat Development Conference this year and renewed its presence at the annual Small Satellite Conference.
- Some leadership changes this year included:
  - o On the Board of Directors, two new members and two alternates;
  - o On the Senior Leadership Team, the president and executive vice president completed their second year;
  - o All major leadership positions are now filled, with a new secretary and treasurer.

AMSAT's Successes at Hamvention

- AMSAT held its first AMSAT Academy in Dayton at the Dayton Amateur Radio Association (DARA) clubhouse with 38 attendees. This is program development for the AMSAT Ambassadors who go out and provide demonstrations, presentations and other community outreach about AMSAT. We now have a standard set of five PowerPoint presentations that the ambassadors can use to put out a unified message about AMSAT and amateur radio satellites.
- AMSAT Academy also serves as a revenue stream. And DARA has offered us the use of their clubhouse again this coming year, an offer that AMSAT will gladly accept.
- AMSAT OSCAR Park was a new display feature this year at Hamvention, and we have replicated here for the symposium.
- The AMSAT-TAPR banquet was well-attended. As you know, we alternate between AMSAT and TAPR hosting the speaker, and this coming year will be our year to host. Spier indicated that he already has an idea for the speaker but needs to nail down that person's availability and calendar commitments before making any announcement.

IT Development Accomplishments

- The board approved a pilot project to get the membership database updated.
- We've made website and online store improvements, specifically updating the platform to all the latest APIs and plug-ins.
- We're looking for IT/tech support for Martha in terms of managing AMSAT's needs.
- AMSAT's social media visibility keeps growing, almost 15,000 followers on Twitter, while the Facebook page has approximately 3300 members.

Membership Trends

- AMSAT membership has fluctuated over time.
- We noticed that the launch of AO-92 had a positive effect on the number of members. And we believe that launching more satellites and offering more digital downloads of resources help increase the membership number.
- Membership support is quite good — whether in terms of dollars or in-kind contributions.
- However, membership dues are not sufficient to fund the organization's operating expenses. AMSAT must rely on investment income to support operations.
- The projected 2019 deficit is approximately $242K, with operating losses covered by reserves and undesignated donations. This is not sustainable in the long term.
- Growing the membership is critical to sustaining AMSAT, with more successful satellite launches providing an opportunity to generate that growth.
- We encourage AMSAT members to recruit others to join AMSAT in order to increase the cash flow needed to pay our expenses.
- We have hired a Vice President of Development who got the board to approve a youth initiative, and we now have help with writing requests for grant funding.
- AMSAT continues to look for ways to encourage donations:
  - o PayPal
  - o AMSAT's online store
  - o The Amazon Smile program
  - o Merchandise sold through Zazzle.com (24% of receipts is a direct donation to AMSAT)
  - o Fundraising is a multi-year effort
  - o AMSAT's new volunteer grant writer

2020 Goals and Expectations

- Launch of Fox-1E (ELaNa-XX) by Virgin Orbit is going up on Cosmic Girl to be launched from Launcher One.
- GOLF-TEE (Greater Orbit, Larger Footprint)— a 3U delivery yet to be scheduled.
- Membership/database improvements will continue.
- CubeSat Licensing: AMSAT continues to provide comments on all of the FCC's notices of proposed rulemaking because we need to protect our spectrum, our reputation, and our good relationship with the FCC, which seems to be paying off.
- We also have good relationships with the communications industry and with the 18th Space Control Squadron.
- ARISS has some new relationships:
  - o Amateur Radio Digital Communications (ARDC) made a very substantial grant to ARISS to help fund its next-generation Interoperable Radio System and associated infrastructure improvements and enhancements
  - o ARISS Education handles the school selection process to evaluate school applications
  - o New hardware is now expected to launch on SpaceX's CRS-20 in March 2020
  - o ARISS-I has formed a new ARExploration Technical Team that is working on ConOps and development of a mission on the Lunar Gateway.
  - o Next Generation Radio Fundraising

Goal of >$150K has been met as a result of the ARDC grant.

• "A Vision to the Future"
o Content management for our media outlets — soliciting materials
--AMSAT Journal (Joe, KB6IGK)
-- AMSAT website (need content manager/aggregator)
-- Seeking content, expanding sources, sharing resources (AMSAT-UK)
o Building awareness and support for AMSAT
-- Social media reach — Facebook, Twitter
-- Translating "likes" to membership support
o Is an AMSAT Communications Strategy needed?
o AMSAT Ambassador
-- AMSAT Academy developed modular presentations
-- Ambassador call sign badge
o International collaborations — major programs in collaboration with AMSAT-UK, AMSAT-DL, JAMSAT, and Radio Amateurs of Canada (RAC)
o Partnerships
o Expand use of Fox transponders on university CubeSats
o Focus on GOLF Engineering
-- AMSAT has moved toward its new program, "GOLF"
-- Need new talent/engineers to support it
-- Enhance the management team
--Bring in next generation of leadership
-- Expand the team to spread the workload
o Build on strategic planning
-- Expand participation in the effort
-- Maintain momentum
-- Develop "wins" that generate confidence
• IT development
• Membership enhancement
• Partnerships
-- How do we force ourselves to focus time/resources on both "short term" and "longer term" goals?
-- Master planning
• Developed 5-year plan
• Work now begins on a 10-year vision
o Worldwide contests with anniversary certificates — W3ZM 50 in 50 States, Original Certificates
o 37th Annual AMSAT Symposium and Annual General Meeting
-- Arlington Hilton, Balston, DC Metro Area October 18-20, 2019
-- "OSCAR Park"
-- Special guest speakers from the formation of AMSAT
• Lance Ginner, K6GSJ (Project OSCAR)
• George Jacobs, W3ASK (Author, Diplomat)
• Dr. Perry Klein, W3PK (Founding President, AMSAT)
• Dr. Owen Mace (Australis-OSCAR 5 builder, University of Melbourne)
• Richard Tonkin (Australis-OSCAR 5 builder, University of Melbourne)
• Jan King, W3GEY (Founding member of AMSAT and Australis-OSCAR 5 Project Manager).

How AMSAT Members Can Help in 2020

• Recruit individuals to become members, rebuild the base.
o Member's word of mouth is most effective recruiting tool.
• Recognize that satellite projects are multi-year projects that require financial support each year.
o Capital campaign programs provide specific funds for satellite projects.
• Donate to our launch campaign for GOLF and future opportunities in 2019, 2020 and beyond as you are able.
• Use/operate AO-91 and AO-92, AO-7 (Mode A/B) and other existing satellites — rebuild interest in amateur radio in space.
• Write articles for the *AMSAT Journal.*
• Provide content for the website/webpage updating.
• Volunteer your time and talent, identify a need and work to resolve it.

Spier concluded his report with reflections on the meaning of the term "amateur radio" as it relates to AMSAT. He noted that the word "amateur" derives from the Latin root word "amatore," or "for the love of," rather than the colloquial meaning "unprofessional."

"So, literally, 'amateur radio' is the love of radio," Spier asserted. "We do this for passion. We have a passion for amateur radio in space," Spier continued. "That is what we do. We have passionate opinions within this organization. We need to find ways to communicate our passion to each other and cooperate. And that's my message to the membership."

Educational Relations Update

Alan Johnston, Ph.D., KU2Y
Vice President, Educational Relations

It was great to see everyone at the 50th Anniversary AMSAT Space Symposium in Arlington, Virginia, last month. It was a fantastic event, and there were some excellent presentations by students, including those from Bishop O'Connell High School in Arlington, Valparaiso University, and Villanova University.

We presented three talks relating to the AMSAT CubeSat Simulator. One was by Bishop O'Connell High School students about their activities with a loaner simulator, and their future ideas and plans. The other two were by Pat Kilroy, N8PK, and me, where we reviewed the past twelve months of activities around the simulator and discussed recent updates and improvements. The new Fox-1 satellite emulation modes are described in an article in this month's Journal.

In the future, we will be building four more loaner simulators, so there are plenty for classrooms, club rooms, and STEM events. Contact me at ku2y@amsat.org to make arrangements.

I am very excited that we now have the AMSAT logo Remove Before Flight tags available on the AMSAT online store at www.amsat.org/product/amsat-remove-before-flight-keychain/ as shown in Figure 1. Look for them on CubeSat or CubeSat Simulator, as well as more information about plans for a future AMSAT education program, coming soon!

Figure 1 — AMSAT logo Remove Before Flight tag available on the AMSAT online store.

Engineering Update

Jerry Buxton, N0JY
Vice President, Engineering

Engineering Presentation at Symposium

For those of you who were not able to attend, the video of the AMSAT Engineering presentation at the 2019 Space Symposium and Annual Membership Meeting is available on YouTube. I helped Paul Stoetzer, N8HM, a bit, by extracting my portion of the presentations from the captured stream of the Saturday afternoon activities and tweaking the audio level and noise, so you can blame me for that.

The video appears on the AMSAT channel on YouTube, youtube.com/amsatna, and I encourage you to watch that first, as I will reference some of what was said there in this column.

Several AMSAT Engineering Team members attended the symposium. Just a week or two before the event, in polling the engineering team about who would be there and who had something to present, we realized we had a substantial amount of information to share. Still, most felt that they did not necessarily have enough material prepared to constitute a separate individual presentation. This resulted more from a lack of available volunteer time to create a presentation as well as working on the GOLF project. I proposed the idea of a group presentation, which we have done in the past. I prefer that format in talking about our project(s), and everyone agreed to gang up on the audience. I requested 75 minutes, and we all met the night before to go over a general plan that would allow each of them some time to show and tell about what they do.

You can blame Joe Spier for my poking Eric in the back and otherwise pushing everyone else who spoke in order to keep things moving in an attempt to shorten the 75 minute engineering update to 50 minutes, when he asked me just before we were about to start our presentation to trim it so he could add another speaker after us. It was worth it in the end because Dan Schultz provided an excellent closing presentation.

We have a great team of skilled engineers, and we had enough time for a few of them to discuss the GOLF systems they are working on. SDR presents many engineering workstreams, and GOLF-TEE has the capability for X band downlink as well as developmental work allowing uplink on several bands. The uplinks are to be used in full on GOLF-1, but not expected to be available in time for operation on GOLF-TEE. With the requirement of rapid deployment of GOLF-TEE, we must make our commitment to develop and test the attitude control and deployable solar panels that are necessary for SDR and microwave operation at the higher altitudes we are seeking in the GOLF program.

"Rapid deployment" is a relative term used to denote our desire to get to orbit as soon as practicable, depending on what is being developed and the nominal time it takes to complete the project. Two or three years from the commencement of work is what I consider rapid for a team of volunteers working on a new project in their spare time. The excitement and ideas are at a high level, and we plan to consider the design and use of GOLF-1 based on what is learned in GOLF-TEE. That is what generates ideas, such as the use of microwave bands, that have been part of the GOLF-TEE presentations.

The need to meet that rapid deployment date requires discipline to assure the requirements for GOLF-TEE and avoid scope creep, especially with a new design. As such, while you hear about capabilities with the SDR on GOLF-TEE, they are not intended to be part of the project, so don't be disappointed when they are not available after launch except for the 10 GHz experimental downlink.

We are fortunate to have launch opportunities provided by NASA through their CubeSat Launch Initiative (CSLI) and Educational Launch of Nano Satellites (ELaNa) programs. To show that we are worth the time and money NASA spends in supporting those programs, at the time of acceptance into the programs, we are obliged to meet the requirements and deadlines set forth by NASA to be manifested on a launch. CSLI acceptance and the ELaNa program provide the opportunity for a launch but do not guarantee a launch. If we want to use our prospects for a free launch, we must make good on the plans submitted in the CSLI and the expectations of NASA.

We have established a solid record and reputation with three CubeSats in the ELaNa program so far, and we sure want to extend our record! That may well be an inconspicuous thing that I have to ensure, which makes me look like the bad guy who doesn't care about these things like more bands on GOLF-TEE or designs that do not include the CubeSat equivalent of the kitchen sink.

The GOLF project was planned to work within the AMSAT budget. The budget I presented at the annual board meeting held just before the symposium is based on accomplishing the goals of the GOLF project within our means. That, too, places limits on what can be done with any particular satellite project, especially when we need expertise or systems that we do not currently have the in-house capability to build. And these limitations rule out CubeSat "kitchen sinks."

As AMSAT's fundraising plans and capability grow with the new push for raising funds in addition to membership dues, there may be possibilities as we play along the front nine of GOLF in which we can purchase or partner with vendors of systems that, like the ADAC, we need but do not currently have the capability of building for ourselves. This could accelerate our reach for higher orbits; however, the expense of any particular mission may result in fewer missions or longer gaps between missions as the coffers are replenished.

The cost of an AMSAT mission may be insignificant compared to many other CubeSats. Still, it requires an increasingly bigger piece of AMSAT's budget as we produce larger, more complex CubeSats, even with a launch grant. GOLF is already a stretch to our current financing capability, which, as I mentioned, is one of the reasons that the program is what it is.

To reach a HEO orbit will likely involve some payment for the actual launch, even with an ELaNa grant. Commercially available propulsion and attitude control solutions are very expensive relative to what we have experienced in our CubeSat projects so far. Radiation-hardened components that will be necessary to ensure the survival and function of even just a few critical systems, in an orbit beyond LEO that may pass through the Van Allen belts a few times per day, are quite pricey as well. When planning our mission to HEO, we cannot afford to be minimal in terms of amateur radio capability, nor can we afford the mission to suffer any failures.

A look at our history clearly shows how even what might be considered small failures from an overall engineering objective standpoint can have a significant negative effect on membership and support. AO-40's failure had a huge impact, despite it being a fantastic achievement during the time that it was operating. Fox-1Cliff's partial (but

significant) failure still generates bad press a year after launch, and in today's internet media, such negative publicity also produces adverse effects on membership and support. Gaining financial support from large donors will not last long if a significant investment turns up a failure. Mission failures, regardless of their real level of significance, are red flags, especially when coupled with negative publicity. That would likely guarantee the loss of future major funding and could put a stop to any desire or attempt to correct the problem and try again.

The failure may well be insignificant or a rally to meet the challenge and do it again for AMSAT and the general nerd world. Still, our failures, as well as successes, also reflect upon the reputation of the donors, and we must proceed with that possibility. With all of the above in mind, we also have many influences from members as well as prospective members that affect our program and mission choices.

Five years ago, when I sat here in my office/shack in the early days of Fox-1, many members expressed concern and even outrage that AMSAT was building "simple/dumb/worthless FM birds." Two years later, we had a significant number of new hams joining the amateur satellite fun, and that continued to grow as more Fox-1 birds were launched. The numbers grew to the extent that we had some reversal of opinion in that initial feeling about FM satellites and began to receive complaints that Fox-1E would be a linear transponder while "we need more FM birds!" This is an illustration of the situation we face, as we attract and enable many fellow satellite hams.

Even with that growing number, we still have just a relatively small slice of the overall amateur radio hobby. In our slice, we have some sub-interests from grid-chasing to DX, from microwave to digital, from GEO to interplanetary. You can only fit so much radio into a CubeSat, and that CubeSat can only fly in a single orbit.

Attempting to make everyone happy is at best extremely expensive and at its worst, not what the other 80% of the six example sub-interests wanted. In my job as V.P. of Engineering, I get to recommend the mission possibilities that make the most members happy, can be achieved by our volunteer engineers, and are within our budget. The job is clearly not a popularity contest.

With that, we press ahead with the steps to HEO that is the GOLF program. It takes a lot of time and the right opportunities to reach orbit, and the iterations of GOLF satellites were envisioned to carry various RF payloads to provide different operating opportunities. With each GOLF mission, we can fly something different, unlike the Fox-1 program (except for the bonus Fox-1E, of course). Or we could fly more of the same, both to satisfy the need to learn and improve and the desires of the members using the satellites. We are seeing success in finding rides for radios — the Fox-1E derived linear transponder, for example — that will help keep amateur radios headed to orbit while we work on the longer-range projects. And there is no doubt that the plan will evolve as opportunities, finances, and the capabilities of our volunteers change.

Anticipating Movement

You have probably heard a statement similar to, "One thing you can count on about a launch is that it will always move to the right (further out in time)." While that is often true, it is not always the case, and I do not believe that I have heard such statements in any of our launch campaigns and processes.

One thing that is for sure with secondary payloads, even if the mission is a dedicated rideshare, thinking that you can play the odds and plan your project on the likelihood that you will have more time than given in the initial delivery deadline is just bad management. I have even seen the announcement that a particular launch might move "to the left" under certain conditions, and while that did not materialize, it shows how launch dates are not something to try to outguess unless you own the rocket.

One of the effects of launches falling in the typical move to the right is the sense that nothing is going on with a project. RadFxSat-2 (Fox-1E) is an example of that, still in the mostly-unused (at this time) Fox Labs awaiting the call for delivery and integration for the launch vehicle. The original Mission Readiness Review (MRR) target was September 15, 2017, with completion and hand-off, i.e., in a bag in a box in Fox Labs as she is now, of August 1, 2017.

That date, of course, had slips, which were mostly due to the launch vehicle being new, and understandably took longer than initially expected to get ready to fly our ELaNa satellites to orbit. In that the slips began to be known early on, we were allowed and took some extra time to get our new Fox-1 radio design working and tweaked to be as good as we could, as it too, as every CubeSat we have built, took longer than expected.

MRR finally locked in for July 11, 2018, so we completed RadFxSat-2 (Fox-1E) on June 21, 2018. RadFxSat-2 (Fox-1E) has been in Fox Labs ever since, never seen by anyone but for a brief moment every so often when I peek into the bag to attach or remove the umbilical in keeping the battery maintained. Oh, what we could have done with another year, with the evolution of the linear transponder in preparing the one for HuskySat-1 and even beyond that as we begin providing them to other partners to fly. This scenario was the same in the case of most of the Fox-1 CubeSats.

Much of what we learned from the orbit of a predecessor — A, B, C, D in this case — may have had the chance to be incorporated into the next Fox-1 (as was initially planned for the program). We did not get those chances for the fact that we have been excellent payload customers in completing work and standing ready to go when we were told we should. That's why we didn't change something in a later Fox-1.

eBay Sellers Donate to AMSAT

Are you an eBay seller? One item, ten items, or a full-time business you can donate a percentage of your winning bid to AMSAT.

To do so, do not list your item with the basic listing tool, select advanced tools. eBay will give you a warning message that it is for large volume sellers, however this is where the eBay for Charity tool is found.

You can "select another nonprofit you love" and search for either AMSAT or Radio Amateur Satellite Corporation. Choose the percentage amount of the sale you would like to donate to AMSAT, and boom!.

When your item sells and the winning bidder pays, eBay will deduct the percentage from your take and forward it to AMSAT.

Sometimes we are getting rid of our old equipment, sometimes selling something new. In any case, please consider giving a piece of the pie to a new satellite and choose AMSAT for your eBay Charity.

User Services Update

Robert Bankston, KE4AL
Vice President, User Services

As 2019 comes to a close, so does my first year as AMSAT's Vice-President of User Services. All I can say is "What a year!" Between learning the intricacies of my new job, getting to know all the wonderful volunteers who unselfishly give so much of their time, and celebrating AMSAT's 50th Anniversary, 2019 definitely will be a year to remember.

Before volunteering for AMSAT, I never knew what went on behind the scenes. After all, as a satellite operator, I only had to turn on my radio, point my antenna to the sky, and everything worked. Little did I know that AMSAT had an army of volunteers working to make that happen. I am proud to now be a part of that team and only hope I can continue to provide the level of service you expect and deserve.

Since my last update, I have been hard at work hosting our second AMSAT Academy of the year, coordinating AMSAT's 50th-anniversary events, and serving not only our members but the entire AMSAT community. In September, I was able to take a trip to Albuquerque, to host an AMSAT Academy at the 2019 ARRL New Mexico State Convention and Duke City Hamfest. What a beautiful venue and an excellent opportunity to share my excitement for amateur satellite operations. Saturday was demo day at the Hamfest. Dan Eggert and his AC9E battle station provided FM satellite demonstrations while I worked the CAS-4A and CAS-4B birds on my trusty pair of FT-817s and Arrow Antenna. Dennis and I had a lot of fun. We felt so honored to meet so many hams and share with them how easy it is to communicate via amateur satellites.

September and the first part of October kept me busy with wrapping up the "Hit the Road with W3ZM" campaign (see the separate article in this issue). I set a goal of having AMSAT's W3ZM call sign operate from all 50 States in our 50th year, and, to be honest, I was getting a little nervous when we got down to the last half dozen. Numerous emails and frantic calls for help on AMSAT-BB and Twitter paid off. AMSAT members, once again, proved why this is such a great organization to be involved with. My sincerest thanks go out to all the activators and chasers. What a phenomenal event, celebrating AMSAT's 50th Anniversary.

Figure 1 — Dan Eggert, AC9E, providing satellite demonstrations at 2019 Duke City Hamfest, Albuquerque, NM.

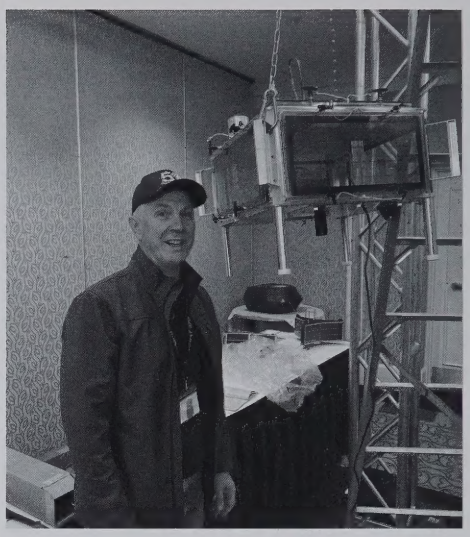


Figure 2 — Robert Bankston, KE4AL, and ARISSat-1 in OSCAR Park.

In mid-October, I found myself in Washington, D.C., our nation's capital and the birthplace of AMSAT, for the 2019 AMSAT 50th Anniversary Space Symposium and Annual General Meeting. Technically, we were in Arlington, Virginia, but everything is so close, the boundaries often blur. On the way there, my flight was weather-delayed, so I did not arrive at the hotel until 4 am. Two alarm clocks and a wake-up call made sure I was not late for the board of directors meeting, which started at 8 am.

The board meeting started with the election of officers. I thank the board members for their confidence in me by not only reelecting me to the position of Vice President of User Services but also electing me to replace the retiring AMSAT Treasurer, Keith Baker, KB1SF/VA3KSF. Thank you, Keith, for your many years of service.

Later that afternoon, I had the opportunity to provide an honest evaluation to the board of what AMSAT User Services does well and what we do not: AMSAT's greatest strength lies in its membership. We are a diverse group, which values and celebrates the individual and group differences within our membership to work towards a common goal of keeping amateur radio in space. Our efforts on social media and event hosting are helping to recruit the next generation are paying off. Every satellite pass proves this point, as you hear voices both young and old. And last, but not least, is our volunteers. They do so much behind the scenes, day in and day out. We truly owe any success to them.

AMSAT User Services also needs to improve

AMSAT® User Services

S Strengths	W Weaknesses	O Opportunities	T Threats
• Members • Events • Social Media • Volunteers	• Member Database • Printed Journal • Old Website	• Member database • Digital Journal • New Website	• Negative Publicity • Inaction

Figure 3 — AMSAT User Services SWOT Analysis.

in several key areas. AMSAT's membership database is antiquated. Costs associated with printing and delivering the *AMSAT Journal* consume our budget. Our website is outdated and does not optimize its value for our members. Fortunately, our weaknesses also provide us with opportunities to improve how we serve our members and the AMSAT community, and I have a plan to fix them.

AMSAT also faces threats that must be either eliminated or mitigated to a point where they cannot harm. The greatest threat AMSAT and AMSAT User Services face is negative publicity. Whether justified or not, negative publicity potentially could cause AMSAT's members, AMSAT's strategic partners, and the entire satellite community to lose confidence in AMSAT's ability to perform its mission. When we fail, we need to own it – admit our mistake and make it right. When unjustified attacks are purposeful, we need to respond to defend ourselves and set the record straight quickly. We can no longer afford to be silent, as we have too much to lose.

After two days of board meetings, it was time for some fun. AMSAT's celebration of its 50th Anniversary effectively culminated at this year's AMSAT Space Symposium and Annual General Meeting, which exceeded our expectations for success. The presentations covered a variety of exciting topics about where we've been, what we are doing now, and what is possible in the future. Many attendees were inspired to see how amateur satellites are influencing students from the elementary to university levels. I am excited about AMSAT's future and was honored to meet the pioneers of amateur radio in space and hear their stories.

Finally, I'm thrilled to announce some major improvements coming for AMSAT members in the coming year. The AMSAT Board of Directors approved my recommendations for an internet-based, member management system, the transition to a digitally delivered, full-color AMSAT Journal, and a complete overhaul of our AMSAT website. I have been putting together these proposals for several months and thank the board of directors for their permission to move these projects forward. These improvements will modernize how AMSAT serves you. I hope that you will be as excited about them as I am.

First up will be an online member management system, which puts you in control of your membership account and allows you to update your contact information, pay your dues, and register for events in real-time. In addition, the program will automatically push out membership renewal reminders, newsletters, and a digital copy of the *AMSAT Journal.*

Printing and mailing our *Journal* represents a significant cost to AMSAT. With these costs continuing to rise, we are faced with the choice of either raising membership dues or finding a more affordable delivery solution. Transitioning to a digitally-delivered *AMSAT Journal* will allow us to provide a full-color magazine without raising the cost of membership. To those who enjoy and look forward to the printed Journal, rest assured, this change will not be immediate. Members will initially receive both the digital and printed, black and white versions of the *Journal.* During this transition period, you may elect to receive only the digital Journal to help us cut costs. At a future date and depending on member-feedback, we hope to be able to switch to 100% digital with a printed delivery opt-in.

Also, we will have the opportunity to provide member-only content on our website, to include back issues of our *AMSAT Journal,* as well as past issues of other AMSAT publications and newsletters. We have a lot of great material to capture, convert to a deliverable format, and upload to our server, so our rollout will occur as quickly as possible. Your patience is greatly appreciated.

Speaking of our website, we are hard at work on building a new AMSAT website. Over the years, our website has received several facelifts, and, in the process, it has become somewhat disjointed. Our goal is to make the navigation more intuitive and offer the most timely and relevant content you want and need. The front of the website will focus on external visitors, explaining who we are, what we do, and what we have to offer. We will also have portals for our members and friends in the AMSAT community, how-to guides on getting started in amateur radio satellites, and all the vital information about current satellites you will need to work them. If you would like to join me in this herculean but well-worthwhile effort, I could sure use the help. I am assembling a Digital Communications Team, to include content creators, content managers, and a webmaster. If interested, please email me at **ke4al@amsat.org**.

Until next time, be considerate of others, look for teaching moment opportunities, and help Keep Amateur Radio in Space!

AMSAT Ambassador Program

Robert Bankston, KE4AL
Vice President, User Services
Director, AMSAT Ambassadors

Do you remember your first satellite QSO, with its steep learning curve and the frustration of not having enough hands to do everything you needed to do all at the same time? While some may have been lucky enough to have a mentor, most of you probably had to figure it out on your own.

Well, now is your chance to share what you have learned about amateur radio in space with others and, in the process, help inspire the next generation of AMSAT members. Become an AMSAT Ambassador and do your part towards making that happen by informing people about its value and encouraging their support and involvement.

Share Your Passion and Excitement for Amateur Radio in Space with Others in Amateur Radio and the General Public

What is an AMSAT Ambassador?

An AMSAT Ambassador is an AMSAT member who wishes to educate other amateur radio operators and the general public about the importance of amateur radio in space and the exciting progress being made in meeting AMSAT's mission and vision.

AMSAT's Mission – AMSAT is a non-profit volunteer organization that designs, builds and operates experimental satellites and promotes space education. We work in partnership with government, industry, educational institutions and fellow amateur radio societies. We encourage technical and scientific innovation, and promote the training and development of skilled satellite and ground system designers and operators.

AMSAT's Vision – Our Vision is to deploy satellite systems with the goal of providing wide-area and continuous coverage – (HEO/GTO/GEO activities – under development as part of the GOLF program), to continue active participation in human space missions – (ARISS, AREX on Lunar Gateway), and support a stream of LEO satellites developed in cooperation with the educational community and other amateur satellite groups – (Fox-1 program, Fox-1 linear transponder communications package for student-led CubeSat programs).

What does an AMSAT Ambassador do?

An AMSAT Ambassador is required to educate other amateur radio operators and the general public on amateur radio in space-related subjects. These presentations must complement AMSAT's goals and meet general proficiency and ethical standards. Being an AMSAT Ambassador requires personal interaction with people in a real-time environment, whether at in-person events, practical demonstrations, online, or in written communications.

Why should I be an AMSAT Ambassador?

Becoming an AMSAT Ambassador empowers you to educate and motivate young people and adults to knowledgeably discuss and participate in supporting amateur radio in space programs. The AMSAT Ambassadors team will give you any guidance and resources you need to enhance your presentation skills and engender interest in amateur radio in space. In addition to the personal growth and satisfaction you will enjoy, you will have the exciting opportunity to interact with diverse audiences and inspire the next generation.

How do I become an AMSAT Ambassador?

To apply, send an email to ambassadors@amsat.org, with the following information:

- Name/Callsign
- City, State and Grid
- Preferred email address
- Satellite experience — FM, Digital, Linear, Telemetry?
- Types of activities you are interested in — Presentations, Demonstrations, Hamfests, Skype, Social media?

50 States in Our 50th Year

On the road with W3ZM

Robert Bankston, KE4AL
Vice President, User Services

Fifty years ago, the Radio Amateur Satellite Corporation or, as we all affectionately call it, AMSAT, was formed in Washington, D.C. To commemorate this momentous occasion, we needed something BIG! We already had 50th-anniversary events planned for Hamvention and our Space Symposium, but we wanted something in between and, more importantly, something that would allow all our members to participate. We needed an operating event.

What better way to celebrate 50 years of "Keeping Amateur Radio in Space," then to get AMSAT's call sign, W3ZM, to operate from all 50 States, and AMSAT's birthplace, Washington D.C., as a lead up to the 2019 AMSAT 50th Anniversary Space Symposium and General Meeting, to be held in Arlington, VA, October 18 – 20, 2019.

One of the great things about AMSAT is that its membership is diverse and widespread. However, loaning out our call sign all over the world for activation was problematic. We decided that operating from U.S. territories would be much easier, so we invited activations in Puerto Rico, Guam, American Samoa, the U. S. Virgin Islands, and the Commonwealth of the Northern Mariana Islands, as well.

We put out a call to our members to take W3ZM on the road in hopes that they would activate not only their home states and territories but also cover those places that lacked an active AMSAT member. They did not disappoint.

I am proud to announce that AMSAT members overwhelmingly answered the call. Not only did they take W3ZM on the road through all 50 states, Washington, D.C., and Puerto Rico, but they helped many AMSAT operators complete their ARRL Worked All States (WAS) – Satellites award.

To all our W3ZM/p activators – THANK YOU! Donating your time, driving great distances, and, for some, interrupting your family vacation to put W3ZM on the air made this a fun, highly successful event.

Help Celebrate AMSAT's 50th Anniversary
Hit the road with W3ZM!

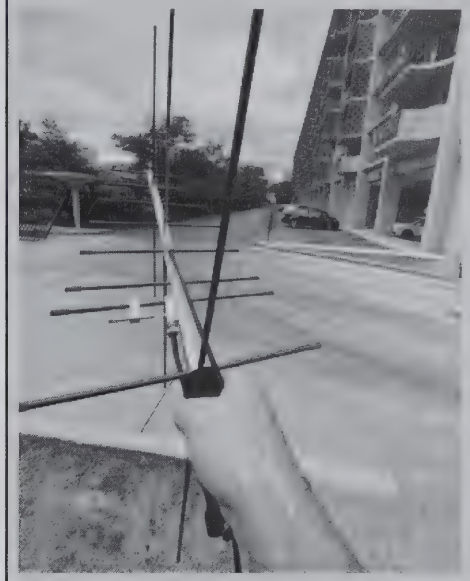
AB1OC	KE4AL	KQ2RP	W5CBF
AD0DX	KE8FZT	N1AIA	W5PFG
AD0HJ	KF7R	N4KGL	WA5KBH
AK4WQ	KG5CCI	N6UA	WB1FJ
K0FFY	KG5GJT	N7AGF	ND0C
K2MTS	KI5BEX	N7EGY	WB9V
K6FW	KI7UNJ	N8HM	WN9Q
K8BL	KM4LAO	N8MH	WY7AA
KB2YSI	KO4MA	N9IP	
KC9VGG	KP3A		

W3ZM Activators — You are indeed an asset to AMSAT and the entire AMSAT community!

W5CBF, Hector Martinez, and WA5KBH, George Carr, operating in Louisiana as W3ZM/5

WB1FJ, Burns Fisher, and AB1OC, Fred Kemmerer (not pictured) activating Rhode Island as W3ZM/1

AMSAT Executive Vice President, Paul Stoetzer, N8HM, had the privilege of activating the last two states, Maryland and Delaware, on October 7th, and Washington, D.C., on October 10th through 12th. Coincidently, Paul's D.C. W3ZM activations took place outside the very apartment building where one of the first meetings was held to form AMSAT in early 1969. It could not be more fitting than to cap off our 50 States in 50 Years event where it all began.



N8HM, Paul Stoetzer operating as W3ZM in Washington, D.C.

Smile for AMSAT at Amazon.com

When making purchases from Amazon, you can select a charity and Amazon will donate .5% of a qualified purchase towards that charity. Select smile.amazon.com when making your Amazon purchases and make Radio Amateur Satellite Corporation (AMSAT) your chosen charity.

Having selected a charity, when you go to amazon.com, you will be prompted to go to smile.amazon.com. However, you can put everything you want in your cart at the original amazon.com site, then leave the site and go to smile.amazon.com and all your items will still be in your cart.

Marketing/ Development Update

Frank Karnauskas, N1UW
Vice President, Development

Space is hard. We know that to be true, and we have known it for a long time. What we also know, and we find it becoming more apparent in recent years, is "Space is expensive." It has become so expensive that the time has come for us to examine our business model and find ways to increase our funding sources within the amateur radio community and develop new sources of funding outside our traditional sphere of operation.

After reading President Joe Spier's Apogee View asking for marketing help last spring, I decided one year of retirement was enough and, with a fresh resume and a draft marketing plan in hand, met with Joe at Hamvention in May. Not long after that, I received the honor of being elected by the board of directors to the position of Vice President, Development, for which I had asked. "Development," you say? What happened to "Marketing?" Since the real goal of this job is fundraising, I asked that we name this position with a moniker that is familiar to philanthropic and corporate grant-giving entities.

Marketing – A Two Way Street

A common misunderstanding of marketing's role is that it is simply an in-house advertising agency that informs the public what we as a company have to offer, and why they as customers should buy it. That is an essential part of the job, but only half of what marketing does. Marketing also discovers the needs of customers and what needs are not being served in the current marketplace. So, marketing works with management to modify or improve existing products or develop new ones to satisfy the unmet needs of customers. Sometimes that means developing a product or service that customers never really thought about until someone puts the idea in their head, and then they can't seem to live without it (smartphones, anyone?)

Where Is The Opportunity?

After using professional tools to survey government and philanthropic grant-giving organizations, it doesn't take long to realize that the line of agencies willing to fund radio satellites so hams can talk to each other is a pretty short line. In fact, it doesn't exist at all. Some government grant money is available for scientific research involving CubeSats, and it is worth keeping an eye on. Writing proposals for government grants, however, is not for the faint of heart, and winning government grants requires such extensive infrastructure for recordkeeping and reporting that such grants are almost exclusively awarded to top-tier research universities. The only realistic way to get some of that funding, even if only indirectly, is by partnering with such research institutions. In fact, AMSAT does have certain Memorandums of Understanding in place with several universities.

So, we keep on looking. What does our survey of grant-giving agencies tell us? Aha! Programs offering innovative experiences for STEAM (Science, Technology, Engineering, Arts and Math) related activities are actively sought and handsomely funded. This line goes down the hall, down the stairs, out the door and down the street. Add special attention to providing such experiences for girls and minority populations, and the line of willing donors grows even longer. We are fortunate that these generous funding opportunities align perfectly with AMSAT's purpose of "Developing and providing satellite and related equipment and technology..." and "Encouraging development of skills and the advancement of specialized knowledge in the art and practice of amateur radio...."

How Do We Respond?

AMSAT, of course, is uniquely positioned to provide those unique STEAM-related experiences by the very nature of what we do. Yes, robots are cool, but anybody can do robots. Space and satellites are cool, too. Just look at the reaction of kids when they participate in an ARISS school contact. We just need to give kids more meaningful opportunities to experience the thrill of space and satellites. AMSAT can do that, and when we do, we fulfill our mission of keeping Amateur Radio in space.

Appealing To What Kids Are Already Interested In

One of the realities that any marketing campaign faces is appreciating the cost of developing a new market. Compared to what the smartphones they already have in their possession can do, let's face it...a two-meter handheld doesn't look all that fun. Basing a campaign on ham radio would be a long and arduous road with probably limited success.

Satellites look like more fun, especially with all the current interest in returning to the moon and even venturing to other planets. It's in the papers every day. How do we get kids to take a closer look at satellites?

Every major news outlet has reported that what kids are most interested in today is saving their planet. What does this have to do with satellites? You already know how satellites are crucial to researching climate change, controlling pollution, preservation of natural habitat, and protection of wildlife. Throw in some applications such as broadcasting, search and rescue in the wilderness and astronomy, and we've got an interesting story to tell.

Announcing The AMSAT Youth Initiative

At the October board of directors meeting in Washington, D.C., the board unanimously approved the creation of a youth initiative that will develop a compelling program for boys' and girls' involvement in satellites. The youth-oriented experiences will use amateur radio as the means to learn about how satellites are designed, built, tested, launched, and tracked. The youth initiative is also responsible for securing external funding needed to design, create and operate the youth-experiences. Those youth-experiences will focus primarily on experiments flown on AMSAT satellites. The Vice President, Development, will coordinate with AMSAT Senior Officers in this development.

Introducing KIDZSAT™

To focus our message and to give it an identity, we have created the brand name KIDZSAT. This brand will serve as the public identity to AMSAT's Youth Initiative. Arriving at this brand was primarily determined by what .com and .org domain names were available. If you haven't tried finding an available domain name, you might be surprised how few desirable names are left. Cyber-squatters have bought on speculation virtually the entire English language lexicon. And, most other "sat" related domains are already in use by other companies and organizations. Happily, KIDZAT seems to say what we need it to say and has a bit of an edgy feel to it that hopefully will appeal to kids and their families.

In practice, we will use KIDZAT as the public face to prospective donors in our public relations and fundraising effort. For interfacing with kids in grades five through eight, KIDZSAT.com will be their portal to our world of satellite-related experiences. For kids in grades nine through twelve, we have registered BUZZSAT.com as

perhaps a more inviting name for more mature students. Our attorney has done a preliminary trademark search, and, with our trademark registration filing in progress, he feels we have a good chance of securing these brands as registered trademarks.

Recruiting Youth Participation

When describing our intentions, I purposely use the term "Youth Initiative" rather than "STEAM" related. The reason for that is when people think of STEAM activities, they instinctively think of its use in schools. Yes, schools are essential, but the reality is not enough of them are promoting STEAM programs to generate the level of youth participation we need to justify the amounts of funding we are seeking. Thus, we plan to develop educational experiences suitable for direct use by kids, their parents and youth-oriented organizations. While schools will always be part of our media mix, our promotional efforts will be heavily directed toward kids and parents who care about their kids' education. We will strive to develop relationships with youth-oriented organizations such as Boy Scouts, Girl Scouts, 4-H, Boys and Girls Clubs, homeschooling organizations and so on.

Fun For Kids, Parents and Educators

As KIDZSAT and BUZZSAT evolve, our plan will feature four layers of involvement:

First, the easiest thing to do to get the ball rolling is to serve as a clearinghouse for existing youth/satellite experiments and curriculum scattered around the web. The amount of material currently available is phenomenal. KIDZSAT will make it easier for kids and their parents to use and enjoy.

Second, we have conceptualized several web-based experiences with which students can explore how satellites are used to address the social issues with which they are concerned. One such concept is based on a fleet of ground-based "virtual satellites" (think enhanced CubeSat simulators) with which students can access online and learn to decode the satellite's housekeeping telemetry and science telemetry and understand its uses. Another concept is to establish a series of web-based downlinks with which students can begin to track live satellites, predict their access times, and download telemetry from live experiments in space. It is at this point we introduce amateur radio as the tool for satellite communication, command and control.

Third, we encourage and give guidance to students to take the ultimate step to communicate directly with the satellites overhead by obtaining inexpensive Amateur Radio equipment and interfacing it with their computers to become bonafide satellite communicators. Suddenly, getting one's Amateur Radio license might make sense to more of today's scientifically oriented youth.

Finally, we aim to provide a means to recognize our participant's accomplishments and encourage them to continue exploring satellites and Amateur Radio. This aspect of the program is not only desirable to keep students active in the program, but it is also necessary to document success to funding organizations.

The Next Steps

The purpose of the Youth Initiative is to provide a common focus for everything we do to keep Amateur Radio in space. The Youth Initiative supports AMSAT's ongoing programs such as ARISS, Deep Space Gateway, Fox and GOLF.

Making sure the Youth Initiative reaches its goal of helping AMSAT prosper for the next fifty years takes a serious effort in fundraising and growing our team of engineering, operations, educational outreach and administrators. In the next issue, we will look more closely at actual fundraising activities and opportunities for everyone to participate in this game-changing effort.

In the meantime, I encourage you to contact me with your questions or comments at n1uw@amsat.org.

Frank Karnauskas comes to this position with a forty-five-year career as a sales and marketing executive in the consumer and industrial markets. As a parent, Frank was active as a local leader in Cub Scouts and a contributor to youth programs as a member of Optimist International. He was first licensed in 1963 and has been a long-term member of the ARRL and lifetime member of AMSAT.

Share Your Experiences as an AMSAT Member

The AMSAT Journal is looking for you to share your satellite radio experiences, likes and dislikes, how you work the birds, and what you like about *The AMSAT Journal*. We'll publish a selection of responses in upcoming issues of the Journal under a column we're calling "Members Footprints." Photos are strongly encouraged! Thanks!

Please send the information requested below to journal@amsat.org --

- Your Name
- Call Signs Held
- Primary Grid Square
- Favorite Satellite Contact
- First Satellite Contact
- First Satellite Ground Station Description
- Current Satellite Ground Station Description
- Reasons You Are an AMSAT Member
- Favorite AMSAT Memory (a satellite contact, symposium, engineering project, event that would never have happened without AMSAT, etc.)
- Favorite Topics Appearing in The AMSAT Journal (could include things like building a homebrew antenna, assembling a ground station, using tablets and smartphones, news of upcoming launches, portable operations, ARISS, etc.

Please Provide a Hi-Resolution Photograph (see www.amsat.org/?page_id=1709).

For Beginners – Amateur Radio Satellite Primer II

Keith Baker, KB1SF/VA3KSF, kb1sf@amsat.org

[The bulk of this article was published previously as "Working Your First Amateur Radio Satellite (Part II)" in the February 2010 issue of Monitoring Times, *Brasstown, NC 28902.]*

Greetings and welcome once again to the Beginner's Corner of the *AMSAT Journal*! My goal in this series of articles is to help beginning satellite operators (or would-be beginners!) demystify the world of amateur radio satellites by sharing a wealth of practical information about how to listen for (and work through) our ever-expanding fleet of OSCARs (Orbiting Satellites Carrying Amateur Radio). I'll be examining some of those satellites currently in orbit, as well as those still on the drawing boards or presently being prepared for launch.

I trust my first article in *The AMSAT Journal* served to whet your appetite about how to listen for and use these largely home-brewed, modern-day wonders constructed from aluminum, silicon, glass and other electronic components that many people have labored long and hard to put into orbit (and then command) for our use.

However, before you progress further, I need to share a few more considerations and tricks of the trade with you so that your attempts at hearing or working through one or more of our so-called "EZ Sats" will be more successful.

One Arrow version sports a 10W 2m/70cm duplexer tucked inside the handle under a removable foam grip. This allows for a single feed line to connect the antenna to a "rubber duckie" connection on a handheld radio.

Some Additional Handheld Antenna Considerations

First, let me say right up front that, in satellite work, your antennas are, without a doubt, the most essential part of your station. That's because the power output of the majority of amateur satellites now in orbit seldom runs more than a watt or two. Indeed, two of the satellites I mentioned in my previous article — AO-91 and AO-92 — typically transmit with a power output of only about ½ watt or so. The power output of SO-50 is even lower.

What's more, all of these satellites transmit into either a single, quarter-wave whip or (in the case of SO-50) what's called a "turnstile" antenna array that usually consists of a set of four; quarter-wavelength 2 m or 70 cm whips canted inward (or outward) at a 45-degree angle on the bottom of the spacecraft.

But, unfortunately, even with their multiple elements, the nominal gain of these arrays is still pretty close to zero. The result is that most of these satellites are transmitting with little more than "flea power" into a proverbial "wet noodle" for an antenna. And if transmitting with low power wasn't enough of a hurdle to overcome, it is important to remember that most of our satellites are in what we call a low Earth orbit (LEO). This means that the bulk of them will never be closer to you than about 500 miles (800 km) even when they are directly overhead. And they'll be over 2,000 miles (3,200 km) distant when they are near the horizon.

So, it should go without saying that you will need a good receiver and some sort of gain antenna in your setup to hear them reliably. And, as you might guess, the "rubber duck" antennas that usually come supplied with most handheld radios are simply not large enough to routinely hear or communicate through these satellites, except under absolutely ideal conditions. By "ideal," I mean with the satellite located almost directly overhead and with just a few other people using the transponder.

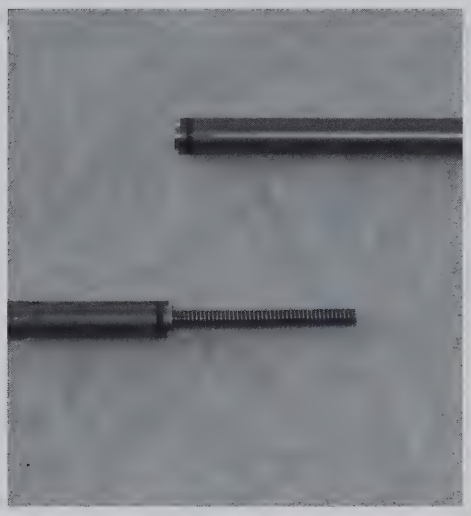
The author's satellite "hand shack" consists of an Arrow Model 146/437 Antenna and a Kenwood TH-78A dual-band handie-talkie (HT). The antenna easily breaks down into several pieces for easy transport. [All photos courtesy of Keith Baker, KB1SF unless otherwise noted.]

The Harsh Environment of Space

Another consideration you must take into account concerns the harsh environment of space where our satellites operate. For example, when their solar panels are in full sunlight, these satellites are being "baked" at about 250 degrees Celsius. When they go behind the Earth and out of direct sunlight, the external temperature of these satellites rapidly cools down to a temperature near minus 250 degrees Celsius! Such rapid temperature swings would soon destroy the fragile electronics onboard if something weren't done to move heat around inside the spacecraft.

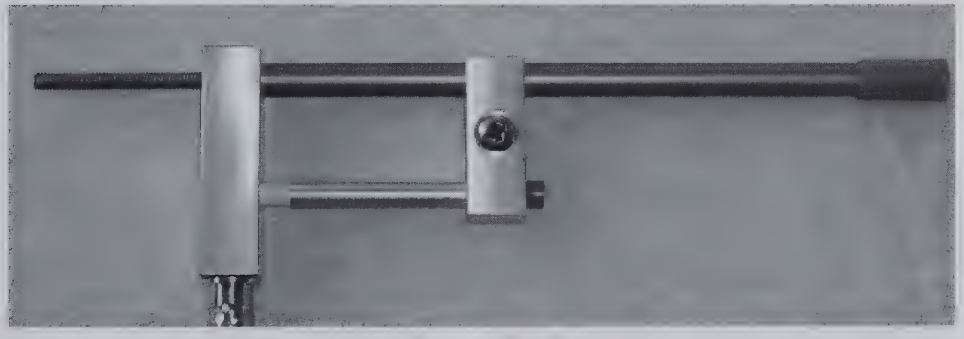
As we all know, high temperatures can very quickly destroy the modern semi-conductor components in our equipment. That's why most modern ham transceivers come equipped with a fan or metal heat sink of some sort. However, it's important to remember

The author's assembled Arrow Antenna with Kenwood TH-78A HT attached.



The Arrow's elements are nicely machined from aluminum arrow shafts, hence the name. Threaded elements easily slip through the boom to provide a secure connection to their opposite element on the other side.

Removing the duplexer and foam grip reveals screw holes for mounting the Arrow Antenna on a lightweight photo tripod.



The Arrow features beautifully machined gamma-matching stubs for both the 2m and 70 cm feeds. Note the 70 cm feed stub.

heat sinks and fans are both designed to work with air. Unfortunately, there's no air in space to cool such components in the same way as we do on Earth. So, our satellites need to dissipate all of that blistering excess heat they get from the sun in some other way.

Likewise, such things as batteries do not operate at all well in the cold. Anyone who has tried to use a battery-powered, modern digital camera outside in sub-zero temperatures knows that you have to keep several sets of batteries in a warm pocket or two if you ever hope to capture more than one or two photos under such conditions.

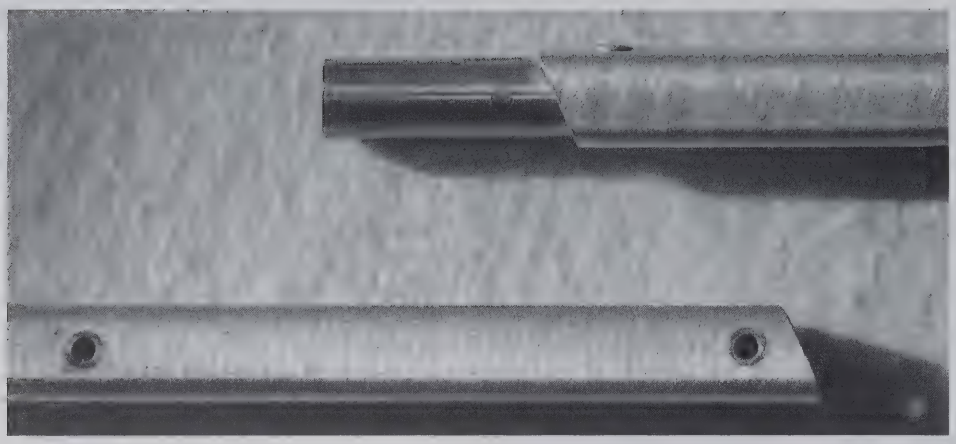
So, with our satellite batteries baking inside a metal box at 250 degrees Celsius in full sun (and then freezing at minus 250 degrees during eclipse), just imagine what they and other electronic components go through on every orbit! That's why our AMSAT satellites (and, indeed, most others) are all designed to tumble or spin (much like a barbeque rotisserie does) as they orbit the Earth. This motion helps to move heat and cold around the satellite's innards evenly (usually by direct thermal contact of internal components to the space frame), to keep the batteries and other electronics inside the satellite heated and cooled within their proper operating parameters.

This is also one of the main reasons why simply sticking a couple of cheap, off-the-shelf, VHF/UHF ham transceivers into a metal box powered by some surplus store nickel-cadmium batteries, adding a bunch of solar panels and then mounting the whole thing on a rocket and launching it often results in a highly unreliable satellite. While such "cobbled together" satellites may work in orbit for a time, they usually don't work for very long!

Doing the Tumble

Furthermore, to keep their downlink antennas properly oriented toward the Earth, some of these birds (like SO-50) are also designed to slowly tumble end over end as they move from South to North (or North to South) over the planet. While also contributing to balancing out those rapid heating and cooling cycles caused by the sun's radiation, in the case of SO-50, this tumbling motion also helps keep what meager gain its transmit antennas are radiating pointed back down toward the Earth and us.

Unfortunately, this constant (and sometimes random for the CubeSats) tumbling motion means that the polarity of the satellite's receiving and transmitting antennas will be



An optional version of the Arrow sports a tight-fitting, split boom feature.

The Arrow mounted on a photo tripod.

An optional carry bag keeps all the disassembled Arrow elements together for easy transport.

continually changing as it moves overhead. And, as satellite work is line of sight, unless you are able to change your antenna's polarity in sync with the satellite, its downlink signals will undergo some very deep fades in your receiver due to severe (sometimes as great as 5 or 6 dB) antenna cross-polarization effects during the course of the satellite's pass.

So, while they will work for "hit and miss" satellite contacts, my experience has shown that most fixed and mobile vertical antennas are not good enough to overcome these limitations. That's because they usually cannot be easily (or rapidly) tilted to match the ever-changing polarity of a satellite's transmit and receive antennas as it tumbles across the sky.

For this same reason, quarter-wavelength and 5/8-wavelength HT-mounted whips are also not recommended for such activities, either. Besides being frequently cross-polarized with the satellite's antennas, most handheld radios don't provide the required ground plane for such antennas to be fully capable.

And, finally, because the downlink signal strength of most of these satellites is so weak to start with, most scanners (or other, so-called "broadband" receivers that cover 145 or 436 MHz) will usually not be able to reliably receive the downlink with just a whip antenna (even an external one) because their unamplified receiver gains typically aren't high enough to do so.

The bottom line here is that, no matter how you cut it, satellite work is weak signal work. And while little whip and "rubber duckie" antennas are adequate for most terrestrial applications, they usually don't provide enough downlink gain to be useful for reliable weak signal satellite work beyond casual "hit and miss" contacts.

However, before you say, "I'll never be able to get on the birds" and give up in disgust, let me also say that with the creative addition of a set of small (and relatively inexpensive) Yagi antennas to produce a bit more uplink and downlink gain, your HT can become a very effective Earth station for use with these satellites.

Handheld Yagis to the Rescue!

If you are truly serious about routinely hearing or working through our FM birds with an HT, a hand-held Yagi antenna of some sort will be needed to provide your transceiver with enough effective uplink power (and downlink receiver gain) to reliably do so.

Over the years, many amateur satellite enthusiasts have "rolled their own" hand-held Yagi antennas exclusively to work these LEO satellites. For example, radio hams like long time VHF/UHF enthusiast Kent Britain (WA5VJB) have been freely sharing their learning by publishing numerous plans on the Internet for a series of homebrewed handheld yagis for 2 m and 70 cm made out of easily obtainable materials. These materials include pieces of aluminum ground wire or brazing rod along with scraps of lumber from your basement, garage, or shed (or, when all else fails, from your local hardware store).

In an excellent online article entitled "Cheap Antennas For The AMSAT LEOs" at **www.wa5vjb.com/references/Cheap%20Antennas-LEOs.pdf**, Kent shows how you can easily build a dual-band hand-held Yagi to work the FM birds. Another reliable source of plans for these homebrew antennas can be found in an excellent series

Kent Britain's "Cheap LEO" antenna uses aluminum ground wire and bronze welding rods for elements, with a boom made of wood. [Courtesy: WA5VJB.]

AMSAT Board of Director's member Drew Glasbrenner, KO4MA, works the birds using one of Kent Britain's "Cheap LEO" antennas. [Courtesy: WA5VJB.]

of beginner articles on or own AMSAT website at **www.amsat.org/cheap-and-easy-yagi-satellite-antennas/.**

If building your own antenna from scratch isn't your thing, fortunately, several commercial antenna manufacturers cater to LEO enthusiasts. Antennas such as the Arrow model 146/437-10 dual-band handheld beam antenna (sidebar) or the Elk Antenna model 2m/440 from www.elkantennas.com are highly recommended commercial substitutes. Both of these antennas will provide more than enough gain for you to work the FM satellites with a 3-5 watt output, dual-band HT, or to hear them with a handheld VHF/UHF scanner.

Other Helpful Operating Hints

A key point to remember is that when you attempt to communicate through them, these satellites will be spinning and tumbling in orbit, so their uplink and downlink antenna polarizations will continuously be changing. If you are using a whip antenna on an HT to try and listen for one of them, moving your HT around a bit during the satellite pass may be helpful. That motion should result in your (and the satellite's) antenna polarization briefly meeting up at some point. I've also found that reflections from conductive surfaces (such as a car body) will sometimes help improve your received and transmitted signals as well.

The same thing goes if you are using a hand-held Yagi antenna of some sort. Simply flicking your wrist to change the polarization of either the uplink or downlink portion of that antenna may make an otherwise unworkable downlink signal into one that's full quieting.

As I also noted in my first beginner's feature article of the *Journal*, if you are using an HT, you'll also want to use a speaker-mike (or better yet, a headset with a boom mike attached) while working through these satellites.

A boom headset will free you from the task of having to hold an antenna in one hand and your radio near your mouth and ears with the other. Even though they are made from lightweight materials, your arm will get tired after holding one of these antennas for a 15-minute satellite pass, so much so that you will probably want to switch hands a time or two during your contact. Another approach that works well is to enlist the aid of an assistant who can hold your radio (or a small external speaker connected to your HT) during the pass.

Another excellent reason for using some form of speaker microphone or boom headset is that, if you are communicating through the satellite using a full-duplex HT, having your microphone and speaker so close together in the same unit will usually create howls of audio feedback through the satellite when you transmit. Such activity will NOT make you a popular "camper" on the bird!

What's more, because they are so weak, the downlink signals from AO-91, AO-92 and SO-50 are unlikely to be strong enough to trip the squelch on most FM receivers. So, be sure to open your receiver's squelch all the way (until you hear the rushing sound) before you begin listening. When the satellite comes into range of your location, the rushing sound will quiet, giving you a clear indication that you have, indeed, captured the bird's downlink.

Swimming With Alligators

Speaking of capturing signals, it is also important to remember that, because FM signals exhibit a very definite capture effect, there will be times when there are so many people trying to use the bird that you simply won't be able to get into the transponder no matter how hard you try. And you will also occasionally encounter high-powered, so-called "alligators" on the birds. These are people who routinely operate with "all mouth and no ears" and, in the process, end up hogging the bird's FM uplink.

If this happens, just keep trying to drop your call sign in between their transmissions. Or, failing that, try again on another pass when, hopefully, the "alligators" will be out of the satellite's footprint or out to lunch! I've had the best luck on these satellites with my HT and Arrow during less busy, mid-week passes where the maximum elevation angle to the satellite from my location was at least 30 degrees above the horizon.

The author works through the AO-91 Satellite using an Arrow Antenna from the beach at Fripp Island, South Carolina. [KB1OGF photo.]

Also, if you're fortunate enough to be operating from a location within a few hundred miles of ocean coast, you may find it easier to get into these satellites with low power when the bird is out over the ocean than when it's passing over, say, North America or Europe. That's because there will be fewer stations within the footprint to compete with you at that time, and most of those competitors will be farther from the satellite than you are.

What if I Don't Hear The Satellite?

This has happened to all of us at times, so don't give up! Go back and re-check the satellite's operating schedule at www.amsat.org/status/ to be sure that the satellite is active and that you are listening and transmitting on the correct frequencies. Another culprit may be that your tracking software is providing you with erroneous pass data. Double check your satellite tracking program to be sure that you have a fresh set of Keplerian elements loaded, that your location file (station latitude and longitude or Maidenhead Grid Square entry) is correct and that you also have the proper GMT versus local time offset loaded into the software. And don't forget to take into consideration Daylight Savings Time at your location.

It is also important to remember that transponder schedules and pass times for these satellites are all expressed in GMT and will vary from day to day...that's why you need computer software to track them. I can't begin to tell you how many times I've gone outside to work one or more of these satellites only to find I was listening for them at the wrong time or on the wrong frequency. All of which proves that even former AMSAT presidents (like me) are well capable of falling victim to such simple errors.

For best results, update your software's uploaded Keplerian Element files (I also briefly discussed Keplerian Elements in my previous article) at least once a month. If you don't already have a computer tracking program, check out the software tracking offerings at the AMSAT store at **www.amsat.org/shop/** and obtain a copy of AMSAT's SAT-PC32 software. For a small monetary donation to AMSAT, you can download the software from AMSAT's website or order a CD-ROM directly from AMSAT headquarters.

What's more, the AMSAT website sports an online tracking display at **www.amsat.org/track/index.php** for many AMSAT satellites (including AO-91, AO-92 and SO-50). Use the drop-down box under the map display to select the satellite you wish to track. I routinely use it as a quick cross-reference to what my computer's tracking software is displaying to make sure I have everything in my computer set correctly. The orbital position of the satellite you are tracking with your computer software should roughly match what's being displayed online by AMSAT.

Looking Ahead

By the time my next installment appears, I hope to have contacted many of you on one of our EZ Sats. In future columns, I'll be discussing some innovative ways to optimize your base station antennas and feed lines to work the birds from inside your shack, as well as to pass along some other "tricks of the trade" to make your beginning satellite contacts more frequent and enjoyable. See you then!

The Arrow II Satellite Antenna Model 146/437 provides an impressive forward gain of approximately 10.3 dBd at 70 cm and 4.6 dBd at 2 meters. Sturdily machined from aluminum arrow shafts (hence the name), this antenna actually consists of two antennas mounted at right angles to each other on the same boom, a three-element Yagi for 2 m and a seven-element Yagi for 70 cm. A removable foam handgrip and threaded horizontal and vertical photo tripod mounting holes underneath the handgrip make this collapsible antenna also useful for terrestrial radio direction finding or portable emergency work.

Options include a split boom and a removable 10-watt duplexer inside the boom along with an assortment of cloth carry bags. With prices starting at about $75 (minus the split boom and duplexer options), the antenna has, quite literally, spawned a whole new way for thousands of hams worldwide to work the "birds."

I own two of these split-boom and duplexer-equipped Arrow antennas, and I remain absolutely delighted with their performance. One of them, along with my Kenwood TH-78A handie-talkie (HT), goes with me in my vehicle or suitcase whenever I travel. Using my Arrow and my HT, I've been able to consistently work through AO-91 and AO-92 down to about 10 degrees elevation.

Several amateur radio dealers offer various versions of the Arrow satellite antenna in their catalogs, or they can be ordered directly from the AMSAT store at **www.amsat.org/product-category/hardware/**

New Fox Emulation Mode for the AMSAT CubeSat Simulator

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I. Introduction

The AMSAT CubeSat Simulator is a functional model of a satellite for use in education and demonstrations. A proof-of-concept prototype was shown at the 2018 AMSAT Space Symposium, and the CubeSat Simulator program was officially "launched" at the AMSAT Update Forum at Hamvention 2019 in Dayton, OH. Initially, the authors set out to create this new simulator model to provide functionality similar to the original ARRL ETP CubeSat Simulator built as described in 2009 by Mark Spencer, WA8SME.

We have published a series of articles in the *AMSAT Journal* about the AMSAT CubeSat Simulator program beginning with the November/December 2018 issue and continuing to the present. Each of these articles presents a different feature of the simulator and its accompanying multi-faceted program. The goals and requirements of the CubeSat simulator are well documented in our earlier *AMSAT Journal* articles. At our new CubeSatSim website, cubesatsim.org, we provide links to the Wiki instructions, a repository of our papers about the simulator, and the open-source code on Github. Figure 1 shows the CubeSat simulator.

While the main design of the CubeSat simulator remains essentially unchanged since the launch of the program, updates are in the works. One new development shown at the 50th Anniversary AMSAT Space Symposium is a Transmitter/Filter Board (TFB) that allows for Fox-1 emulation modes.

Figure 1 — The AMSAT CubeSat Simulator.

II. New Transmitter/Filter Board

Our original model used the Raspberry Pi Digital Transceiver Board, a custom printed circuit board designed by Jonathan Brandenburg, KF5IDY, of Brandenburg Tech. We used Jonathan's board because it was available in May 2018 when the new simulator was under development. An attractive feature of his board is its support for various digital modes. At the same time, the 1200 bps AFSK AX.25 telemetry mode in the 70 cm amateur radio band was available as sample code in the DigitalTxRxRPi Github code library, which provided us the opportunity to develop the AMSAT CubeSat Simulator code around it. This combination performed well.

Nonetheless, two factors drove our desire to develop an alternate transmitter board. One was cost, and the other was extensibility. The Digital Transceiver Board is the single biggest cost item in the simulator. Our desire to reduce the overall build cost of the simulator nudged us to examine it carefully. In terms of extensibility, we always planned to support additional modulation schemes so that we could emulate other amateur radio satellites. For example, we had partial success in adding CW encoding, but we ran into difficulties emulating the 200 bps FSK (Frequency Shift Keying) modulation used by the AMSAT Fox CubeSat series. We also were not able to emulate the 1200 bps BPSK (Binary Phase Shift Keying) modulation to be used by Fox-1E (RadFxSat-2) and the University of Washington's HuskySat-1 3U CubeSat, which is flying an AMSAT radio. The difficulty is in programming the AX5043 registers and the lack of documentation available. Also, a core design principle of the simulator is to use software wherever possible, so relying on hardware for modulation violated that principle.

The new TFB uses an all-software approach to modulation that is based around the rpitx library for the Raspberry Pi by Evariste Courjaud, F5OEO, at github.com/F5OEO/rpitx. The TFB uses the Raspberry Pi GPIO clock pin to generate RF signals. This approach is sometimes described as a 1-bit modulator since the generating waveform is a digital square wave. But when an RF square wave is produced, the resulting fundamental frequency is accompanied by many harmonics and spurs at significant levels. So, to use this approach, we designed a simple bandpass filter plugin board that attenuates most of the spurs and harmonics down to substantially lower levels.

We use rptx in the 70 cm ham radio band, centered around 434.900 MHz. We chose this frequency because it is close to the 70 cm satellite allocation (435 - 440 MHz) but inside the unlicensed Industrial, Scientific and Medical (ISM) band at 432 - 435 MHz. We use a simple bandpass filter (BPF) available on the Internet that is centered around 433 MHz with a bandwidth of 2 MHz and a suppression of 30 dB.

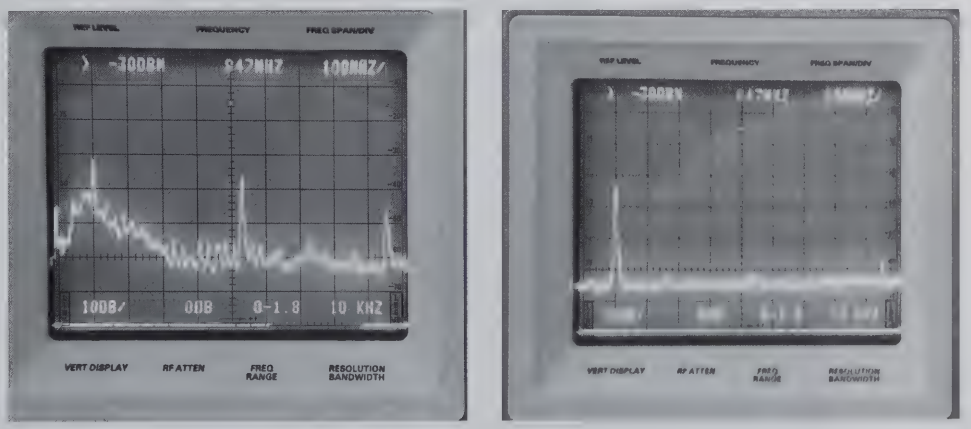


Figure 2 — rpitx 434.9 MHz Transmitted spectrum before and after filtering showing peaks at the fundamental, first and second harmonics.

Figure 3 — New Transmitter/Filtering Board prototype on a Raspberry Pi Zero W.

The left side of Figure 2 shows the spectrum before filtering, as seen using a Tektronix 492P Programmable Spectrum Analyzer. A big thank you to Dr. Robert Caverly, WB4PWZ, for the use of the test equipment in his Microwaves Lab at Villanova University for these test results. The fundamental is the highest peak, one division from the left side. Each division is 100 MHz, so the strong first harmonic can be seen just over four divisions to the right, and an almost equally strong third harmonic on the right side of the display. Also, many spurs appear in the 300 MHz either side of the fundamental. This signal quality is clearly not suitable for the amateur radio bands in any country.

The right side of Figure 2 shows the same signal after being filtered by a $10 Bandpass Filter (BPF). The spurs are gone, and the first and second harmonics are now down 30 dB from the fundamental. The fundamental is about 3 dB down from the unfiltered signal, giving about -30 dBm or 1 microwatt of power. This level of filtering is not quite sufficient for some, but the extremely low power means that this signal is limited to a small room, so the likelihood of interference is very low. In the future, a better BPF design could reduce the harmonics below the typical 40 dB threshold.

See the completed TFB in Figure 3. It is built on a GPIO female header, which plugs into a Raspberry Pi Zero. The purchased BPF has SMA female connectors for input and output. We unsolder the input one using a jumper wire but leave the output for connecting an antenna. In addition, a one kiloohm resistor is placed between one of the GPIO pins and ground. The software reads this GPIO pin at initialization, and only activates the transmitter software if the resistor is detected. This should prevent transmission of the unfiltered signal shown on the left side of Figure 2. An additional GPIO pin is used to drive an LED, with a blue LED used to distinguish it from the previous transmitter board.

This TFB has a cost of around $15, which is significantly less than the $80 of the Digital Transceiver Board. However, the real value is its extensibility.

The rpitx library includes FM modulation and IQ modulation, which can also utilize the excellent command-line SDR library called CSDR (see **github.com/simonyiszk/csdr**) as well for basic DSP and filtering functionality to produce DSB and SSB signals. The FM module takes an audio WAV file and produces Narrowband FM (NFM).

With an appropriate AFSK audio file, generating the 1200 bps AFSK AX.25 telemetry is simple. This allowed us to replicate the current telemetry modulation. Next, we implemented two new modulation schemes — 200 bps FSK and 1200 bps BPSK — so we could emulate AMSAT Fox CubeSat satellite telemetry.

III. Fox Emulation Mode for FSK and BPSK

A goal of the CubeSat Simulator is to provide training and experience that will carry over to using real amateur radio satellites in space. That's why making the CubeSatSim work with the AMSAT FoxTelem software was an important aim (**www.amsat.org/foxtelem-software-for-windows-mac-linux/**). FoxTelem, written by Chris Thompson, AC2CZ, is a multi-platform Java application that takes as input a WAV file, audio card, FunCube or RTL-SDR USB Dongle then decodes, plots, archives, and uploads telemetry for the AMSAT Fox-1 series of CubeSats. Currently, amateurs and enthusiasts all over the world use the free FoxTelem software for the Fox-1A (AO-85), Fox-1B (AO-91), Fox-1C (AO-95) and Fox-1D (AO-92) satellites.

You can see the live results at amsat.org/tlm. Click on the "latest spacecraft health" link to see the telemetry just as it is displayed in FoxTelem for any of these satellites.

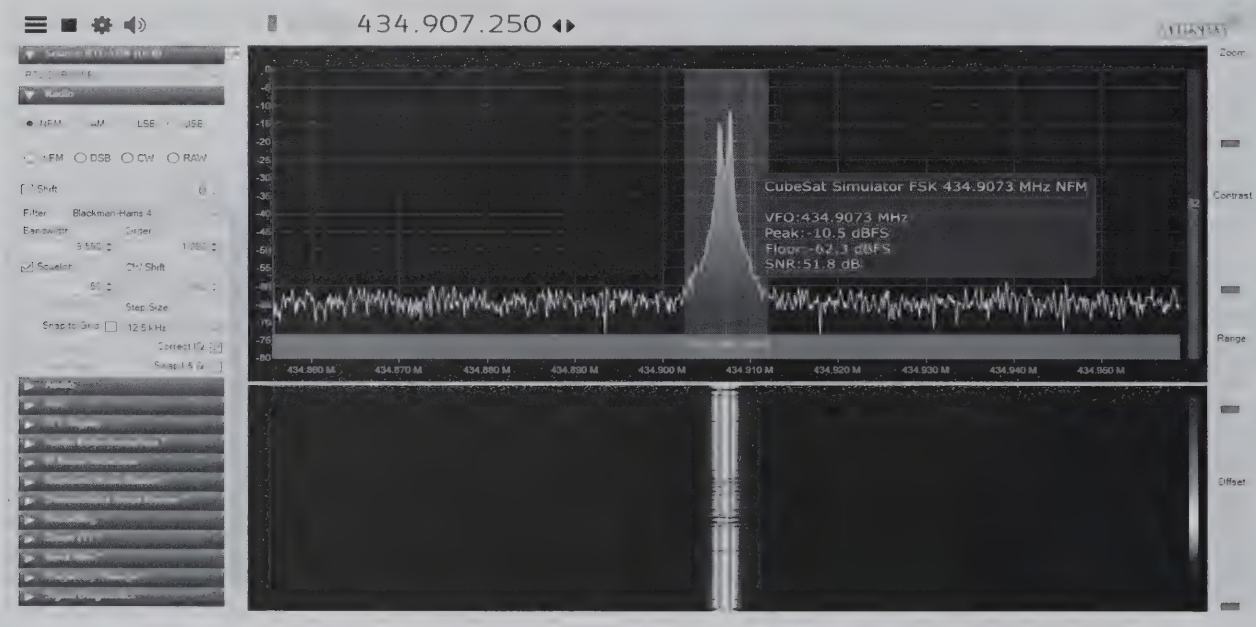


Figure 4 — SDR# of FSK from the CubeSat Simulator.

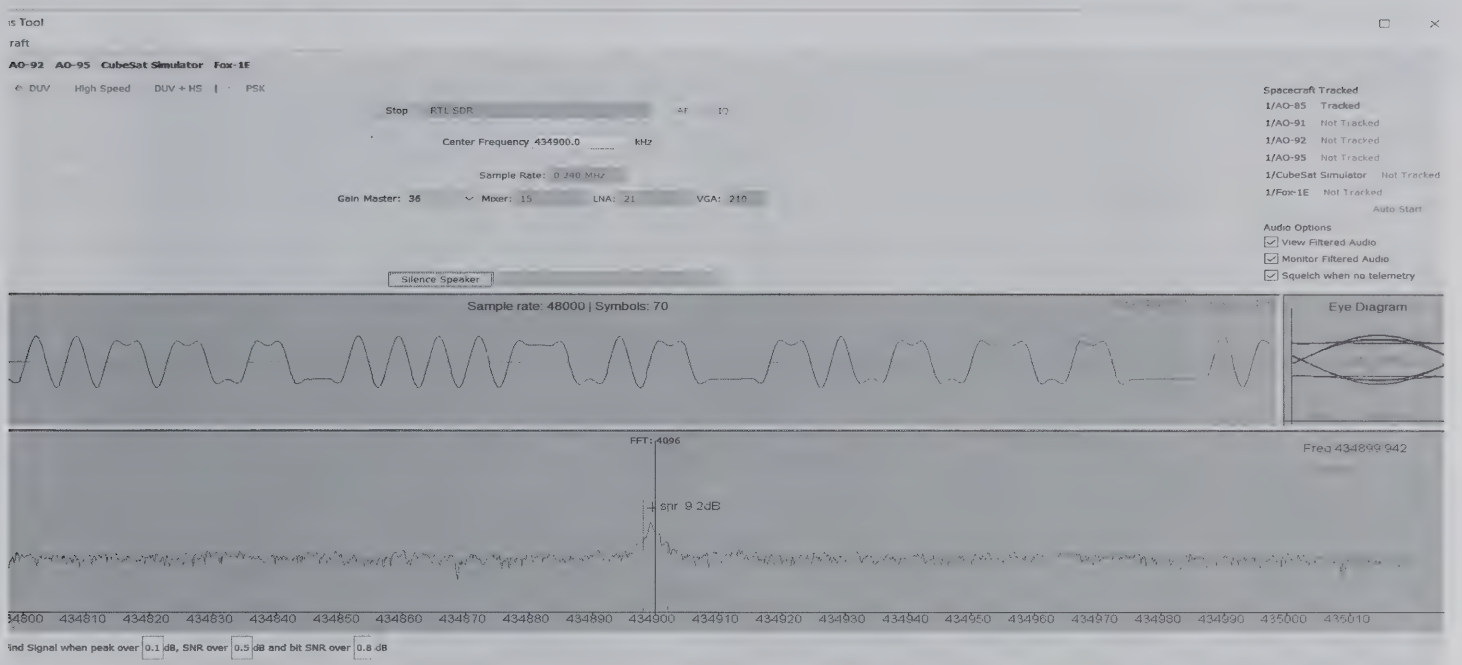


Figure 5 — FoxTelem RTL-SDR Input of 200 bps FSK (Data Under Voice DUV format) Telemetry from the CubeSat Simulator.

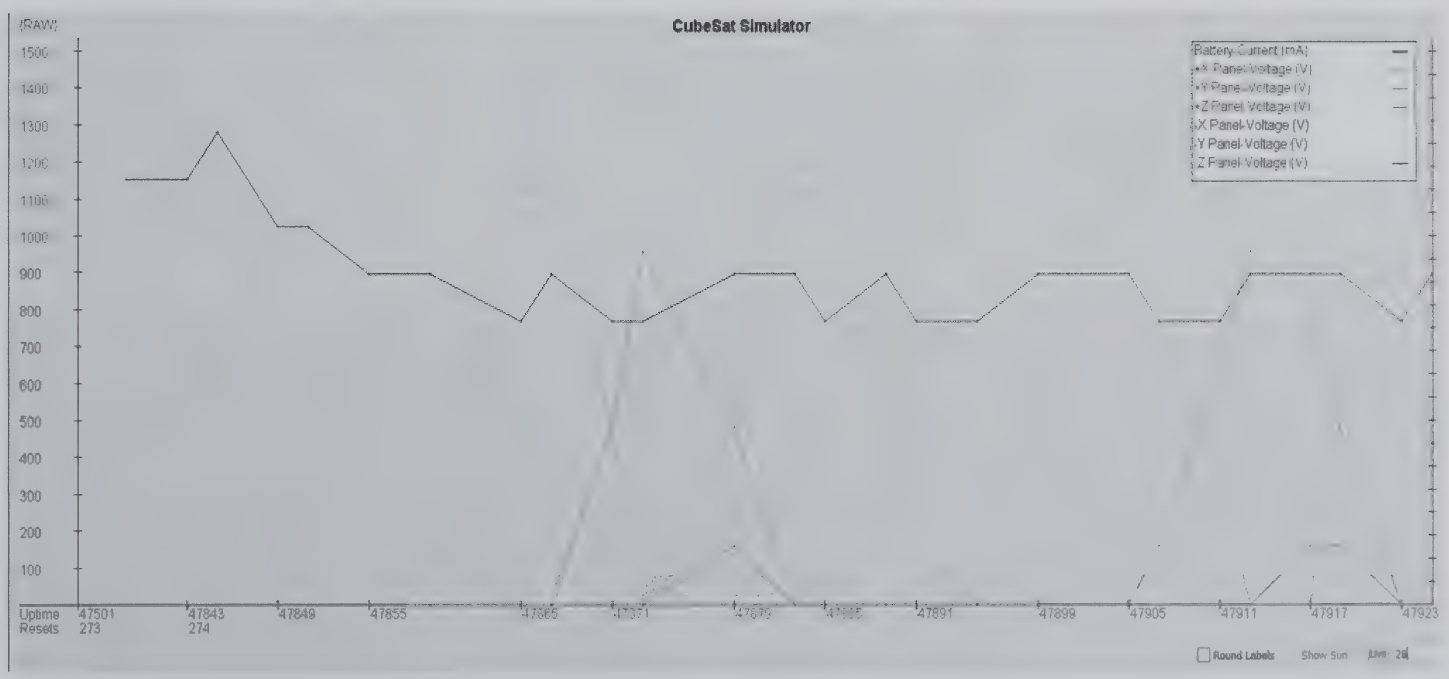


Figure 6 — FoxTelem Current Data from the CubeSat Simulator.

Soon it will also be used for the Fox-1E and HuskySat-1 CubeSats once they are commissioned. With the new TFB and new software, the latest version of the FoxTelem software can now be used to decode and display telemetry generated by the CubeSat Simulator.

FoxTelem supports two modulation schemes, 200 bps Frequency Shift Keying (FSK) used by the FM satellites (AO-85, -91, -92, and -95) and soon the 1200 bps Binary Phase Shift Keying (BPSK) of the linear satellites. The details of these telemetry schemes already have been well described by the engineering teams in previous AMSAT Space Symposium papers and the *AMSAT Journal* so that we won't go into detail here. However, a big thank you to Chris Thompson, AC2CZ, and Burns Fisher, WB1FJ, for their help in figuring out the 8b10b encoding, framing, and Reed Solomon Forward Error Correction (FEC). The simulator code now incorporates open source code written by Chris, Burns and Phil Karn, KA9Q (and probably other contributors too).

A. 200 bps FSK Modulation

For the FSK modulation, we generate a square wave input waveform using differential encoding. We invert the waveform if the bit we are sending is a 0, and leave it unchanged if the bit we are sending is a 1. This signal is then fed into the rpitx application, with the carrier frequency set to 434.900 MHz. Since the simulator code and rpitx are separate applications running on the Raspberry Pi

Figure 7 — SDR# BPSK of CubeSat Simulator.

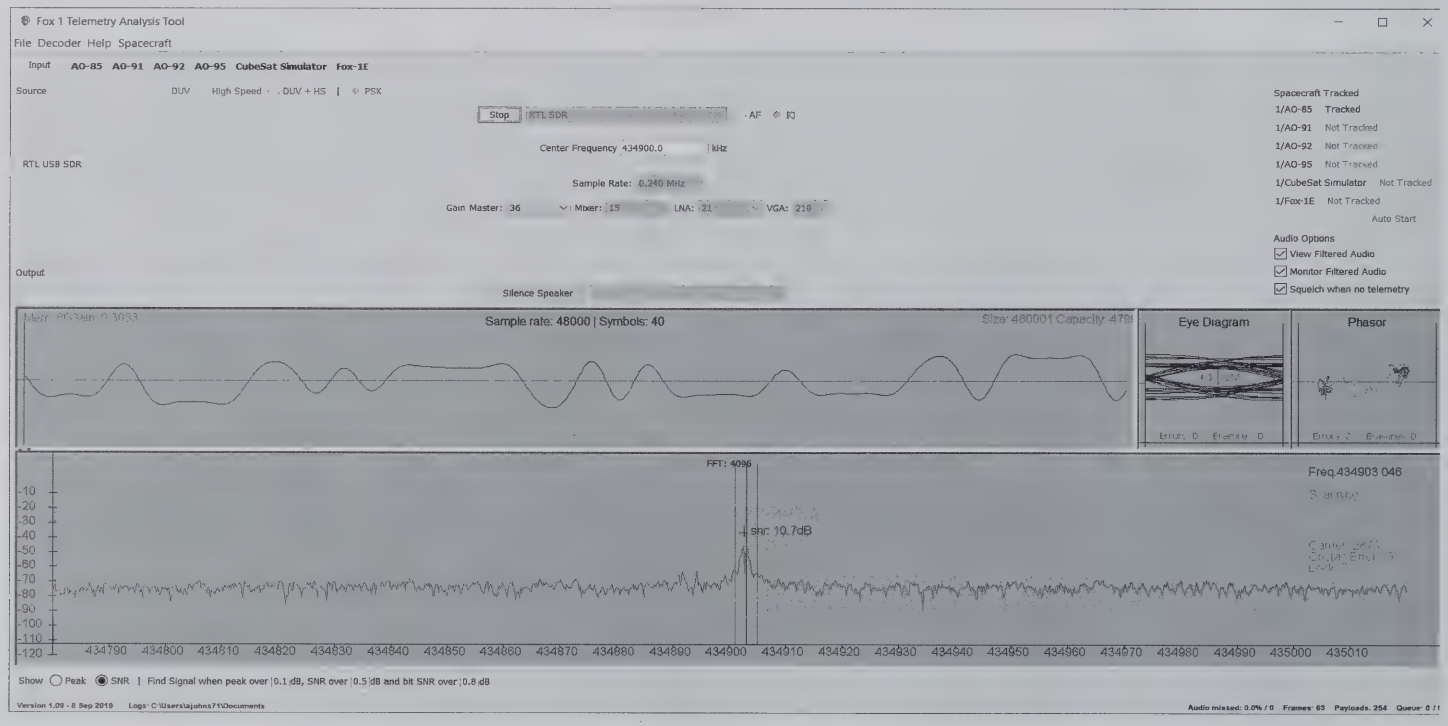


Figure 8 — FoxTelem RTL-SDR input of 1200 bps BPSK (Fox-1E format) telemetry from the CubeSat Simulator.

Zero W, we establish a TCP socket between the applications to pass the data between the applications. See the resulting FSK modulated telemetry signal in SDR# in Figure 4.

When used with FoxTelem, the result is as shown in Figure 5, which depicts the RTL-SDR dongle input to FoxTelem. In FoxTelem, simulator telemetry graphs can be generated, such as the one in Figure 6 showing the six solar panel currents and the battery current plotted. This is very similar to the results obtained with the previous simulator design using the Digital Transceiver Board, SDR# software, VBCable software, AFSK Decoder software, and the telemetry analysis spreadsheet. This is a major simplification! Also, FoxTelem updates graphs in real-time, which is great for displays.

B. 1200 bps BPSK modulation

We used a similar approach for the 1200 bps BPSK modulation. We generate a BPSK waveform by changing the phase of a simple sine wave by 180 degrees, depending on whether we're sending a 1 or a 0. The resulting waveform is then SSB (Single-Side band) modulated at a carrier frequency of

434.9 MHz and transmitted using the TFB. Figure 7 shows the SDR# reception.

The CubeSat Simulator uses a Fox ID of 7 for FSK and 99 for BPSK (each satellite has a unique id value, and these are chosen to not overlap with any existing or future satellite). This will ensure that simulator data is never mistaken for real satellite data.

Real satellite data can be uploaded by FoxTelem to AMSAT servers for archiving and review by engineers. In the future, perhaps we could also upload simulator data to the AMSAT servers. It could be a fun end to a demo or activity to see the data from the classroom or demonstration on the AMSAT page for later viewing or sharing on social media.

By changing the mode from DUV (Data Under Voice, which is FSK) to BPSK, FoxTelem decodes this telemetry as well, as shown in Figure 8.

C. 1200 bps AFSK AX.25 modulation

The new TFB can also be used with the 1200 bps AFSK AX.25 telemetry modulation scheme. We used the gen_packets test application in the DIRE WOLF (Decoded Information from Radio Emissions for Windows Or Linux Fans) application by John Langner, WB2OSZ, at github.com/wb2osz/direwolf to generate the telemetry signal as a WAV file, then used rpitx to modulate the WAV file. The resulting signal is essentially the same as the previous design, although the transmit level is much lower power.

V. Next Steps

A. Development Phase-In of Transmitter/Filter Board

In the near future, both the old transmitter (Raspberry Pi Digital Transceiver Board) and the new TFB will be supported. However, newer emulation modes, such as the Fox-1 emulation mode described in this paper, will only be supported on the TFB. The same software can be used as it will auto-detect which transmitter board is present.

The TFB is being built as a stand-alone GPIO plugin board so it can be plugged into the top of the stack where the Digital Transceiver Board used to reside. For those pioneers who have already built a CubeSat simulator with the original transmitter board, a TFB can be built with a stackable GPIO header. Since there is room inside the frame, this stackable TFB can be plugged in on top of the Raspberry Pi Zero W in the stack and still have the Transceiver Board available. The SMA antenna connector may need to be moved manually or a second antenna mounted.

As for the program, we will gradually add the stackable TFB to the AMSAT loaner simulators to add the Fox-1 emulation modes and a Raspberry Pi ground station. New builders of the AMSAT CubeSat Simulator will have a choice. The TFB is cheaper and easy to build. However, in the future, the Digital Transceiver Board could perhaps be used as a 2-way command and control radio interface with the CubeSatSim.

B. Battery management board replacement

A future step planned to reduce the cost of the simulator is to design a new Battery Management board to replace the MoPower UPS V2 board, which currently costs $60 and handles battery charging, monitoring, and automatic and manual shutdown of the Raspberry Pi. Replacing this board with our battery charging board will further reduce the cost of building the simulator.

C. Next solar power printed circuit board

In the upcoming redesign of the solar power PCB, we will add the Transmitter/Filter functionality to this board, which will reduce the board stack count and further reduce build costs. The newly designed Battery Management Board may also be added to the PCB, reducing the board stack count and cost. A bonus here is that the extra volume might better accommodate an instrument or payload in the 1U frame.

VI. Conclusion

The original design for the CubeSat Simulator has proven to be effective in meeting the goals of the AMSAT CubeSat Simulator program. The design updates described in this paper are enhancements to provide additional functionality and reduce the build cost.

We also plan to make some additional developments in the future, especially around the battery board. However, we expect most of our future development to be in documents and educational materials for teachers and demonstrators of the AMSAT CubeSat Simulator. Then again, we might share additional hardware development surprises along the way, as well. Stay tuned!

Alan and Pat are always eager to hear your feedback and comments on the CubeSat Simulator project. Contact us at **ku2y@amsat.org** and **n8pk@amsat.org**. Also, contact Alan if you would like to borrow a loaner simulator for your event.

N6O/MM DM02 Expedition

Ron Bondy, AD0DX
ad0dx@yahoo.com

I like to rove. It is probably my favorite part of operating amateur radio satellites. I have activated 80 grids twice, including CM93 Santa Rosa Island.

One of the most sought-after grid squares for the GridMaster award is grid DM02 off the coast of San Diego, CA. The only landmass in this grid is San Clemente Island, which is a restricted U.S. Naval Base. Thus, DM02 must be activated from the water.

I work out of my home in Colorado Springs, and my head office is in Orange County, CA. Around September 1, I was invited to a business meeting in Orange County. After my last trip to Santa Rosa Island in August 2019, a few of us on Twitter had discussed activating DM02. Because it was my second successful activation of Santa Rosa Island CM93, I had people sending me private messages on Twitter that they would be glad to contribute $100 towards the costs of a boat for a DM02 activation. This had me wondering if it was possible to activate DM02 only three weeks later.

I reached out to Alex, N7AGF, who I had met in February 2019 while we activated the Peace Park together. The Peace Park straddles the border between Canada and the U.S. between Washington and British Columbia. Patrick, WD9EWK, had activated that location previously, and it looks like a fun spot for an activation because you can operate with one foot in Canada and the other in the U.S. Alex and I hit it off and had a good time operating together, sharing roving stories and getting to know each other.

Alex was also interested in activating DM02, so I started making some phone calls. I called seven or eight charter companies but only heard back from two. I chose to leave from Oceanside, CA, because it is directly across from the grid, and I would be flying into Orange County airport. I discussed the trip to San Clemente Island with a fishing charter and quickly learned that the trip over to the island is five or six hours so that an overnight trip would be required. Mike, W8LID, had previously done an overnight activation of DM02 in June 2017, and now I understood why.

I was quoted $2500 from one charter

company, and the other wanted $250/hr for their boat, which had a special underwater stabilizer. Also, when I mentioned longitude and latitude needed to get into the grid square, that charter asked me if I was a drug runner. Apparently, they get the occasional request to go to a specific longitude and latitude on the ocean to meet a "friend" to pick up a "package." I told him no; we were making radio contacts through amateur radio satellites.

At this point, the $2500 cost was daunting. Still, after having received several unsolicited private messages offering to help with expenses for the boat charter, I was wondering if it was possible to get at least part of the costs of the boat covered by donations from the AMSAT community. I spoke to the owner of the boat, and he is friends with the captain of the boat used for the Clipperton expedition. So, he was somewhat aware of amateur radio and was very excited to be our charter for the trip. To reserve the boat, they want half of the money as a down payment. If the trip is canceled because of weather or a mechanical problem, then you get a full refund.

I spoke to Alex to explain my findings to date, and he was good to proceed, understanding that in the worst-case scenario, we would be sharing the entire costs of the boat. Before I put down my credit card, I wanted to speak to a few more people as a reality check. Robert, KE4AL, and Chris, K7TAB, were kind enough to take time out of their day to speak on the phone with me to discuss the trip and give me their thoughts on how much support we might get from the AMSAT community to offset the costs of the boat. I asked Robert if he thought we might get $1500. He indicated he thought this was a conservative amount. I wasn't sure. I took a leap of faith and reserved the boat for Sunday, September 22, putting down $1250 on my credit card.

As I had been thinking about the trip, I wanted W6O as our special event callsign. But Robert, KE4AL, pointed out I should check to see if it is already in use around that date because then the QRZ.COM page for W6O would not be available. I looked and, indeed, W6O was reserved for Route 66 on the Air and was spoken for through September 21. So while we could have used W6O for the trip, we would not be able to use QRZ.COM leading up to the trip. And given that we wanted to raise funds for the trip, having a web page on QRZ was important. So at that point, I chose N6O as the callsign for the trip. I was already looking forward to saying "November 6 Ocean Maritime Mobile" if we got to activate DM02.

Before I made the announcement for N6O/MM in DM02, I started working on the web page on QRZ.COM. I took a few days to develop the web page and give the background for the GridMaster award and explain about grid squares and why DM02 was so important. I also reached out to Mike, W8LID, to ask some questions and get his input. Because Mike had been there previously, I was glad to learn from his experiences and avoid making any rookie mistakes. Thanks for all your help, Mike. Robert, KE4AL, also reviewed an early version of the web page and made some excellent suggestions that I implemented. Thanks, Robert!

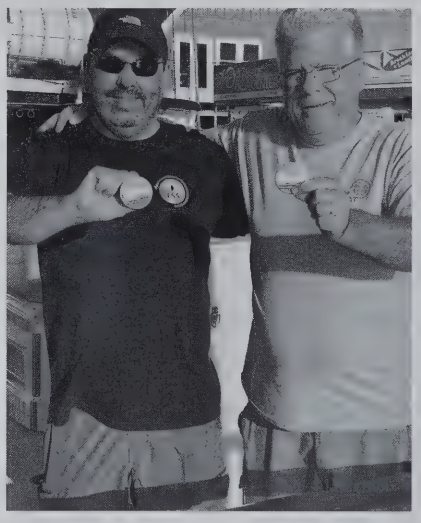
At this point, I was ready to make the N6O/MM DM02 announcement. I first announced on the weekly DMR AMSAT meetup run by my friend Mitch, AD0HJ. After that, I announced the activation on Twitter, Facebook and the AMSAT mailing list. Chris, K7TAB, and Mitch, AD0HJ, both made donations immediately to get the ball rolling. Much to my amazement, every day the donations kept coming in until after only one week, the AMSAT community had donated the entire $2500. To say I was overwhelmed would be putting it mildly. Getting all the money for the boat so quickly was a wonderful surprise. Alex, N7AGF, was also surprised and very thankful.

The charter company scheduled the trip to leave shore at 8 or 9 pm on Saturday and return around 7 pm on Sunday. The grid square begins roughly halfway between shore and San Clemente Island. At this point, I wasn't too excited that we'd be entering the grid around midnight. I hoped that possibly a few AMSAT operators might consider staying up late for DM02.

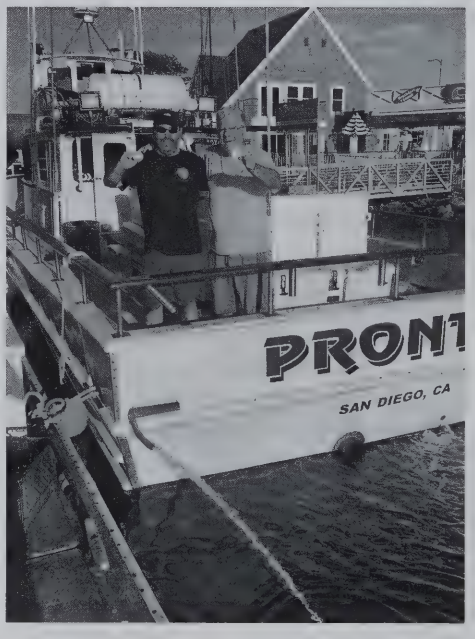
I started doing some pass planning and found that there was a great AO-91 pass for the east coast at 12:30 am PDT. However, I knew from roving to Santa Rosa Island CM93 that if this were the first pass of the rove, it would be overwhelmed with callers from the entire U.S. The west coast stations being closer would be louder, making it more challenging to work the east coast stations. And on a rove like this off the west coast, there is an extra satisfaction working those stations on the east coast due to the greater distance. In particular, I wanted to work Kevin, KK4YEL, in EL98, Florida.

Asking the west coast stations and mid-west stations to hold off for a later pass just wasn't an option. We are all very passionate about chasing grids, and so many people needed DM02. Asking them to wait and risk missing the grid due to weather, a radio problem, or a mechanical problem with the boat would not work. What I needed was another satellite with a low western pass to cover the west coast first. I did some more research and found a great AO-92 pass at 11:15 pm PDT, which was around 20 degrees elevation to the west.

However, we discovered a different problem. AO-92 is usually in L/v mode at that time, and most ops do not have L/v equipment yet. I sent a quick private message to Robert, KE4AL (AMSAT Vice President of User Services), and he said he would look into it. I did hear back from AMSAT on the Friday evening before I left for California that they would leave AO-92 in U/v mode for the weekend. Thank you, AMSAT!



Alex Free, N7AGF; Ron Bondy, AD0DX.



Ron Bondy, AD0DX.

Earlier, I had spoken to the owner of the boat, Ernie, about the importance of making the AO-91 pass. He was very cooperative and suggested we leave an hour earlier at 7 pm to ensure that we were in DM02 for the pass. I did some mental math and felt that if we left at 7 pm, we would be in the grid by 11:00 pm PDT for the AO-92 pass. When we arrived at the dock, and I met our boat captain, Dave. Then I explained that it would be great if we could be in the grid by 11:00 pm. He was a little confused because earlier I had requested we be in the grid by 12:30 am for a satellite pass, and he wondered, well aren't they all satellites? In hindsight, I should have called and discussed this before we arrived at the dock. Captain Dave did some calculations and said we could be in DM02 by 11:00 pm if we went a little faster than usual.

So Alex and I and the crew of three set out for our grand adventure to activate DM02 and anchor overnight next to San Clemente Island. I had told the boat owner and captain that we didn't mind if the crew did some fishing while we worked satellites, so everyone was in a good mood.

Going a little faster leaving the shore to get in the grid had the unfortunate side effect that the boat had a little more up and down motion than it usually would. Alex and I stayed on the boat and talked for an hour or so, and around 8 pm, I headed down to the bunk to get some sleep. Alex stayed up on deck, and later on, I found out that Alex was experiencing some seasickness. I got up at 10 pm to start getting ready for the AO-92 pass and found that Alex was sick in his bunk. So, I would be doing the 11:15 pm AO-92 pass on my own and probably also the AO-92 pass at 12:30 am.

The Pronto has nine bunks, but with only five of us on board, this worked out very well. I decided to assemble my Arrow antenna first and placed it on the bunk above me. Then I set up my FT-818s for working AO-91. I use the 818s for linear and FM satellites. I checked everything over multiple times — FM (not SSB), tone enabled at 67 Hz, etc. Mitch, AD0HJ, had made me a set of custom cables for the trip. I had been using them at home with good results, so I decided to use them as my primary cables on the boat. Thanks, Mitch!

The captain came down to discuss the first satellite pass. I think the crew was excited to be doing something different on the boat. I asked the captain if he could slow down the boat to reduce the up and down motion of the boat. He explained that there was a "sweet spot" for this, and it would mean we would still be in motion. I understood and thanked him for accommodating my request.

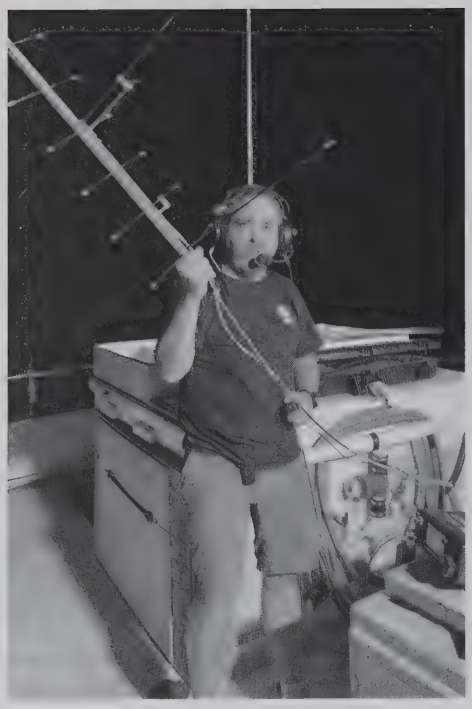
At this point, I had been up since 3 pm California time with a little napping on the boat. I felt good, but of course, was a bit tired and a little concerned that this first pass go well. I asked the captain if it would be possible to steer the boat due west during the 12 minutes of the pass starting at 11:15 pm. This would make aiming the Arrow easier for me; at TCA, the satellite would be straight ahead. The captain did this for me, which I appreciated. I didn't ask him to do this again. But I've never done a satellite pass from the bow of a moving boat on the ocean in the dark, and I wanted to do as much as I could for the pass to be a success.

I moved the Arrow up to the rear deck of the boat around 11:00 pm and then went down and got my Amazon camera bag with the radios, battery and voice recorder. For this trip, I brought my 109WH Bienno battery. It fits perfectly in the camera bag. I had practiced four or five times during the week with this configuration, and it was working well.

I hooked up the Arrow to the radios at about 11:07 pm at the rear of the boat and decided just to turn the radios on one more time before I moved to the front of the boat where I knew the up-down motion of the boat would make operating a challenge. I hit the power button on my 450 MHz tx FT-818 - nothing. Huh? This was one of those times when I was glad that I had activated 80 grids. I didn't panic with the pass coming up in around six minutes. Like most rovers, I have made many mistakes roving: cables going to the wrong side of the Arrow antenna, confusing east for west, LSB/USB reversed on the linear birds, etc.

So, I just took a deep breath and focused on the problem at hand. I had experienced a little trouble hooking up the Bienno battery to the 450 MHz tx FT-818 before I came up on deck. I disconnected a few things and took the battery out and the FT-818 also. In my tired state, I realized that I had the side of the battery with the power pole wires oriented so that side was the farthest side from the radio. Oops. I rotated the Bienno battery 180 degrees, noted that I had a little more slack now in the power poles wiring, plugged the power poles into the radio and reassembled everything. I headed up to the bow of the boat at about 11:13 pm to get ready for the pass. I turned everything on again and started to listen for the satellite.

I really can't describe the relief I felt when I heard Christy, KB6LTY, on the satellite downlink. I think it was at that point that I thought the trip might be a success. Christy was also kind enough to work me as AD0DX/MM so that I could get official rover credit for DM02. After Christy, it was a nice continual stream of experienced operators resulting in a productive 20+ QSO pass. I was so happy and relieved to have that first pass completed. I don't remember everyone I worked, but I know I worked Patrick, WD9EWK, Casey, KI7UNJ, and Kell, KI7UXT. This was perfect. After this pass, all the experienced western ops that wanted the grid now had it, which paved the way for a successful eastern U.S. pass at 12:30 am on AO-91.



As I finished working the pass, I looked over to my right. The deckhand was standing about five feet away from me. The captain must have asked him to come and stand with me to make sure I didn't fall overboard! I was so focused on the pass I didn't notice him until that moment. I let out a whoop and a holler and moved back towards the safety of the back of the boat. As I was putting my equipment down below, the captain came to me and said, "So, you're all done then? You made a satellite contact?" I had to reaffirm that we were just beginning.

Alex was still sleeping below, unfortunately. I'm sure he was disappointed he wasn't able to be up on deck working these first few passes, which were pretty exciting. I put the Arrow back down below on the bunk so it wouldn't be exposed to any water that might splash up onto the boat. Same for the radios in the camera bag. I had about an hour to the next pass and thought that resting down below was best.

Alex has a Garmin InReach that he had brought and set up to broadcast our location every 10 minutes. I had borrowed Robert, KE4AL's, InReach for my first trip to Santa Rosa Island in 2018, so I was familiar with how to operate it. I had told everyone that we would be tweeting passes, so I got Alex's InReach and made a short tweet announcing the AO-91 pass at 12:30 am.

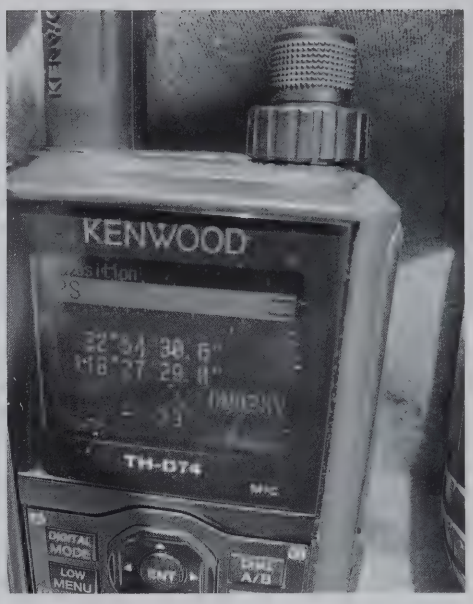
Around 12:15 pm, I repeated the process. I brought the Arrow back up to the rear deck and went and got the radios. The boat was heading roughly west for San Clemente Island, and this was an eastern pass so that I would be doing this pass from the stern of the moving boat. The boat feels more stable back there, and now that we were in the grid, the captain slowed down to conserve fuel and make it easier for us to move around the boat.

The 12:30 am pass was another successful 20+ qso pass. I was able to work lots of ops that needed the DM02 grid, including some closing in on the GridMaster award. Hector, W5CBF, also helped me out by checking the status of FO-29. If FO-29 wasn't available, I didn't want to spend the time or energy setting up and attempting the pass. Hector let me know that FO-29 had been off over the most recent pass over Japan. Thanks, Hector!

At that point, I also decided to work the 1:07 am PDT pass of PO-101. PO-101 sounded great, but that pass only resulted in 3 QSOs. So, after that, I decided to sleep and get up for the AO-7 pass at 4:30 am. I knew that there were a lot of good CAS4A/B passes and XW passes coming up starting at 5 am and thought it was best to get some rest.

Alex and I got up at 4 am for the 4:30 am AO-7 pass, and, thankfully, Alex was feeling better. Alex was going to take the AO-7 pass on his IC-9700. We set up for the pass and quickly found that the 9700 rx was being overwhelmed by the electronics from the wheelhouse. Alex made a few QSOs, but it was challenging. We were not set up for the 9700 to move around the boat, so if the wheelhouse were between the radio and the satellite, this would be a problem. So although we didn't plan it, having the 818's in the camera bag and being able to move around the boat to position the wheelhouse behind me turned out to be a real benefit.

Next up was a CAS-4A/B pass. I set up for the pass with my two FT-818's. I have done a lot of CAS-4A/B passes with this setup, so I was astonished that when I transmitted, I heard static in my headphones. It was very frustrating hearing Mitch, AD0HJ, and Kevin, KK4YEL, work each other and not being able to join in. Alex was there to help, and I unplugged my headset so he could hear the problem. He knew what it was immediately: desense. This was puzzling to me because previously, I had only experienced desense on FO-29, which is V/u. And I had done a lot of CAS4A/B passes without a diplexer with no problems when in U/v mode. Alex had an extra BLP-200 low pass filter, and he got that for me. I put the filter in line. The desense problem went away, and I was able to make the next CAS4A/B pass. I'm guessing the problem



had something to do with moisture in the cables. I live in Colorado and operate mostly in dry climates. I had never operated from a boat on the ocean before. This was made more embarrassing by the fact that I also had a BLP-200 low pass filter I had bought just for this trip, but it wasn't installed because I didn't expect to need it.

At the point, it was daylight, and the crew was up doing some fishing. They were happy to get the chance to fish because usually, they are helping everyone else fish. The crew would have preferred to be able to move the boat to the west side of the island for fishing, but we had explained previously the importance of staying on the east side of the island for the satellite passes.

Alex then worked some SO-50, AO-91, and AO-92 passes using his Kenwood TH-D74. When we were at the island, we had cell phone coverage, and so it was fun to tweet and be able to interact with the AMSAT Twitter community. Mark, N8MH, sent me a Twitter message that he was interested in DM02, so I made it a point to look for him. Being in NC, he had a narrow window on each pass. It felt good to get him in the log.

Back in August 2018, Mitch, AD0HJ, and I (Ron, AD0DX) worked Ruth, KM4LAO, on the same satellite pass. Ruth joked on Twitter after that she should receive an award for working two AD0 prefix stations on the same pass. Mitch and I discussed Ruth's suggestion, and we both agreed it was a great idea. Mitch designed a beautiful "AD0SQUARED" award QSL card, and we now send them out if you work both of us on the same satellite pass. For N6O/MM, we considered suspending the AD0SQUARED award, but eventually, we decided that Mitch

would only work me on CAS4A/B passes. The CAS4A/B birds seemed well suited for this with their west to east orbit. This allowed operators to work Ron on the west coast and then move to Mitch in the midwest (MN). This way, we were not tying up an FM satellite with ops trying to get our special QSL card (and keychain!). When N6O/MM was in DM02, we had 20 QSOs on CAS4A/B birds where ops worked both Mitch and me. As I reflected on this after Mitch tallied up the logs to see how many ops worked us both, I felt that these QSOs could also be viewed as good EMCOMM training. Imagine that Mitch and I were activating at hospitals, and the ops working us were in EOCs spread across the country. If an EOC had traffic for both hospitals, our AD0DSQUARED QSOs show the power of the linear satellites available to us and the skill of the satellite operators on the air today. Kudos to all the operators that worked us both on the same linear pass.

We wrapped up our time at the island at around 11 am on Sunday. By this point, we were confident that everyone that wanted the grid had made the QSO with us in DM02. There was one remaining low eastern AO-91 pass at 11:30 am PAC, and I did that from the bow of the moving boat also. At first, I wanted to use my trusty 10-year-old VX-6R and FT-70D but decided to use my FT-818s again mainly because I was set up to use my Heil headset with those radios. That was a fun pass. It was great to work Anthony, VE2HEW, in Montreal, Randy, ND0C, and his daughter Kylee, KE0WPA, and others. It was a great way to end the trip.

On the way home, the crew cooked us steaks that the owner, Ernie, had offered to provide. I think his crew had been working very hard the past few months, and this was an easy trip for them, with only Alex and me as passengers.

Alex and I would like to thank everyone again that donated financially towards the boat charter. We appreciate the support and everyone staying up and working us through the night in DM02 and make N6O/mm a success.

50th Anniversary AMSAT Space Symposium and Annual General Meeting

AMSAT luminaries and presidents: (L-R): Barry Baines, WD4ASW; George Jacobs, W3ASK; Joe Spier, K6WAO; Perry Klein, W3PK; Keith Baker, KB1SF/VA3KSF; Tom Clark, K3IO; Rick Hambly, W2GPS .

Lance Ginner, K6GSJ, and Jan King, W3GEY.

Hilton Arlington, VA.

George Jacobs, W3ASK, recounting the early years of AMSAT.

Past Presidents (L-R) Keith Baker, KB1SF/VA3SF, Jan King, W3GEY; and Barry Baines, WD4ASW — with spouses.

The banquet concluded with a retrospective of AMSAT's beginnings and the early OSCARs from the founders and builders.

AMSAT VP User Services, Robert Bankston works AO-92 pass outside

The first and current AMSAT president, Perry Klein and Joe Spier.

MacDoppler

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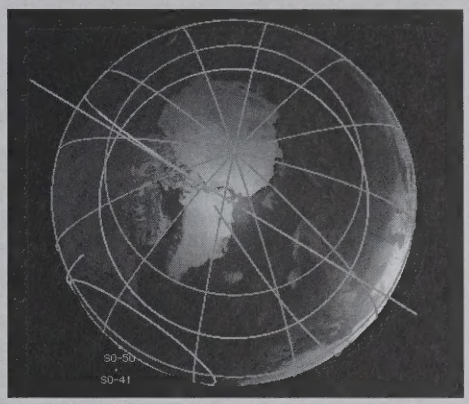

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Support AMSAT

AMSAT is the North American distributor of SatPC32, a tracking program for ham satellite applications. Version 12.8d features enhanced support for tuning multiple radios. Features include:

1. The CAT commands of the IC-9100 have been extended again. The program now also controls the DV mode (DV for 'Digital Voice') of the radio. With the FT-817 the program now additionally supports the CWR mode.

2. All SatPC32 programs now process significantly larger Keplerian element source files. Especially because of the numerous new Cubesats, the number of data sets contained in the source files has increased significantly. For example the file Cubesat.txt currently contains data for nearly 400 satellites.

3. In all programs (SatPC32, SatPC32ISS, Wisat32, WinAOS and WinListen), the list of satellites contained in the source file ('Available' list in menu Satellites) is now displayed in alphabetical order to facilitate locating individual satellites.

4. The program SatPC32ISS now also allows the creation of up to 12 satellite groups. The new Cubesats have also increased the number of 'in-band' satellites. Originally, in-band operation in amateur radio was only available at the ISS.

5. In order to accelerate a change between the individual satellite groups, the 'Groups' window can now be called up by clicking on vacant areas of the main window, except in the Satellite menu. Such free positions are located on the right and left of the frequency window.

6. In the Satellites menu the data sets of the satellites contained in the active source file can now be displayed. When called, the data set of the currently selected satellite is displayed. The feature helps you to immediately know the identifier of the satellite.

7. The program has improved control of the sub-audible tone required by some satellites. The program can now automatically switch the sub tone on/off when switching between PL tone satellites and others, changing between u/v and v/u satellites, changing the group, closing the program, etc.

A registration password for the demo version may be obtained for a minimum donation of $40 for members and $45 for non-members. Order by calling 1-888-322-6728. The author DK1TB donated SatPC32 to AMSAT. All proceeds support AMSAT.

12Volt Portable Dual Axis Rotor System

model: 12PRSAT

If you live in an area where you can not have a permanent outside antenna system; or you enjoy operating portable; or you want to do school and public demonstrations; or a little of each; then this Rotor System might be the solution you have been looking for.

Feature Rich and designed to support popular antennas like the light weight Elk Log Periodic to the larger Alaskan Arrow up to the largest supported antenna, being the M2 LEO Pack.

(Optional Universal Mount with M2 Antennas)

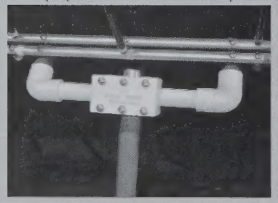
(Antenna, feed-line, mast and stand not Included)

Basic Features Include:

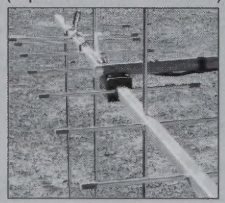
- USB computer interface supporting popular tracking applications (GS--232A Protocol)
- Low Power 12 Volt (12-14VC) operation
- Light Weight and designed for Portable use
- Included Mag/Accel Sensor Module used for fast deployment and tracking accuracy
- Simple to use 3-Button control interface using a single 4 conductor control cable

(Optional GPS Module)

(Optional Elk Mount)



(Optional Arrow Mount)



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AMSAT GOLF $125,000 Development and Launch Initiative

AMSAT is excited about developing and launching the next generation of Greater Orbit Larger Footprint ("GOLF") satellites. AMSAT has an immediate need to raise funds to cover development, launch and related expenses for GOLF-TEE and GOLF 1. We have set a fundraising goal of $125,000 to cover these expenses and help us to continue to keep amateur radio in space.

GOLF-TEE (Technology Exploration Environment) will be a rapid deployment to LEO to establish/verify/learn ADAC, Deployable Solar Panel Wings, Radiation Tolerant IHU, SDR.

GOLF-1 is planned as an approx. 1300 km LEO, progression of GOLF-TEE technology, first STEM mission with VU and APS, AO-7/FO-29 supplement, and our first "High LEO" CubeSat.

Donations may be made through the AMSAT webpage at **www.amsat.org**, by calling (888) 322-6728 or by mail to the AMSAT office at 10605 Concord Street, Kensington, MD 20895, USA. Please consider a recurring, club, or corporate donation to maximize our chance of success with this mission.

AMSAT President's Club
Support GOLF-TEE and GOLF-1

Contribute to AMSAT directly through easy, automatic charges to your credit card. Since AMSAT is a 501(C)(3) organization donations may be USA tax deductible. (Check with your tax advisor.) To join contact Martha at the AMSAT Office by phone (888) 322-6728 in the US, or (301) 822-4376; e-mail **martha@amsat.org**.

Titanium Donors contribute at least US $400 per month	❒	$400 / month
	❒	$4800 one time
Platinum Donors contribute at least US $200 per month	❒	$200 / month
	❒	$2400 one time
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	❒	$1200 one time
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	❒	$600 one time
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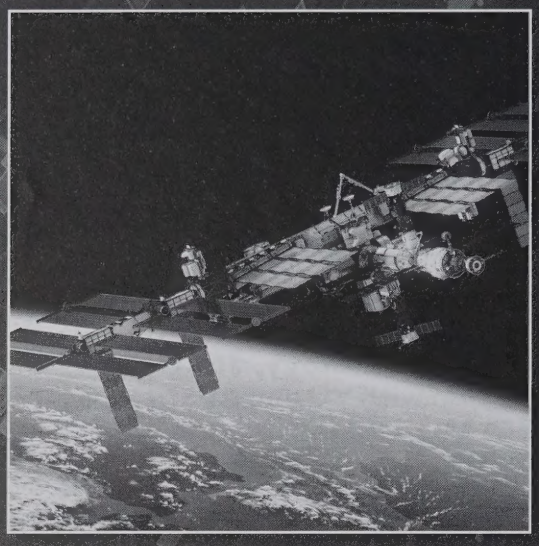
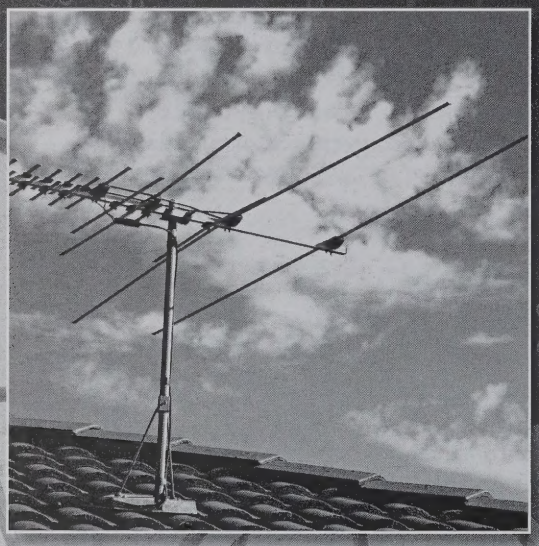
	❒	$300 one time
Core Donors contribute at least US $10 per month	❒	$10 / month
	❒	$120 one time

Your help is needed to get the AMSAT GOLF-TEE and GOLF-1 Cubesats launched.

For the latest news on GOLF watch our website at www.amsat.org, follow us on Twitter at "AMSAT", or on Facebook as "The Radio Amateur Satellite Corporation" for continuing news and opportunities for support.





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Build satellites that Keep Amateur Radio in Space!

Promote space education through ARISS and STEM-based initiatives.

Manage satellites in orbit and ensure they are available for public use.

Create and maintain vital partnerships with government, industry, educational institutions, and amateur radio organizations to foster space research and communication.

Learn, teach and share innovations and best practices in space communications with other radio operators, students, government and the public.

Show and share their passion for amateur radio in space everywhere they go!

Will take amateur radio to the Moon, to Mars and to deep space … with your help!

Go to https://www.amsat.org/volunteer-for-amsat/ and help create AMSAT's future legacy!

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